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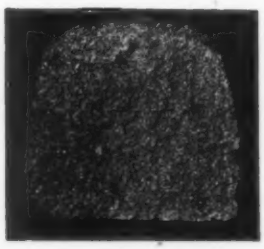

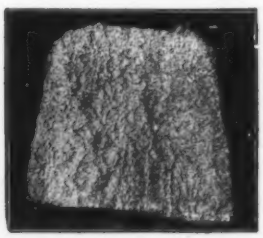

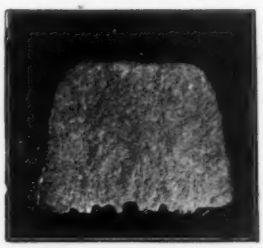

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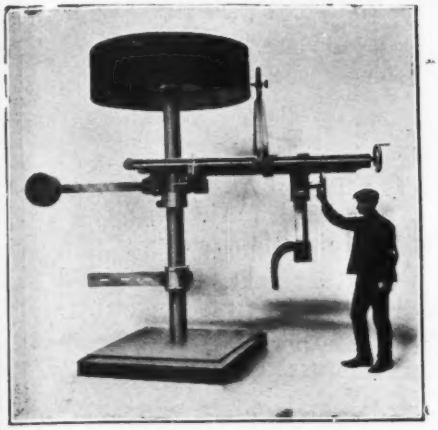

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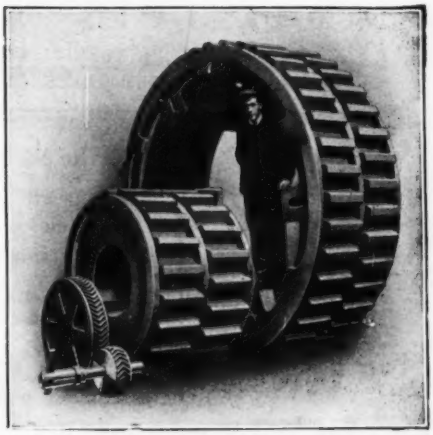

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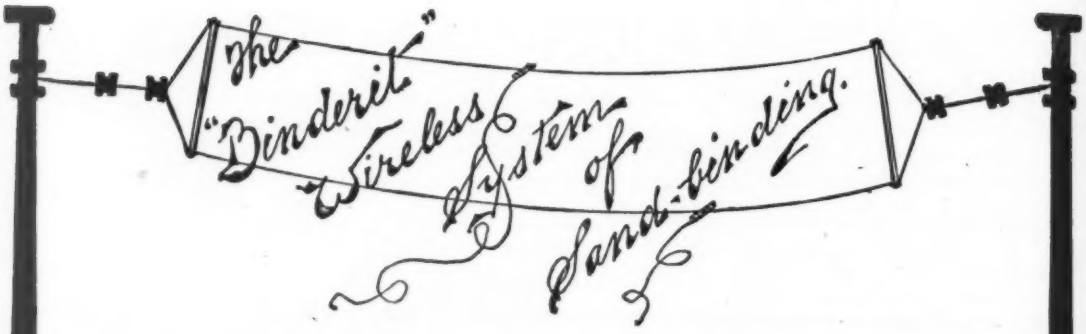

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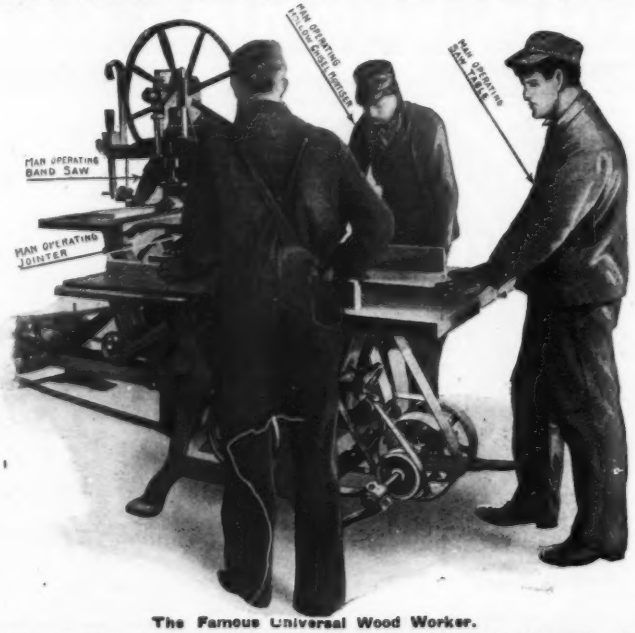

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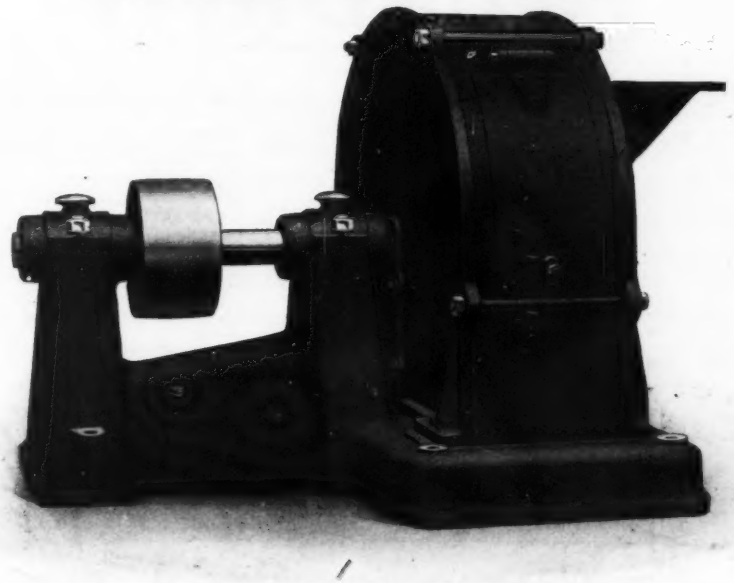

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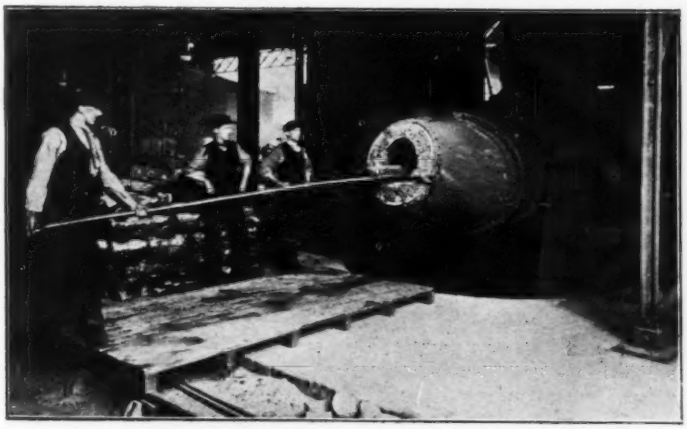

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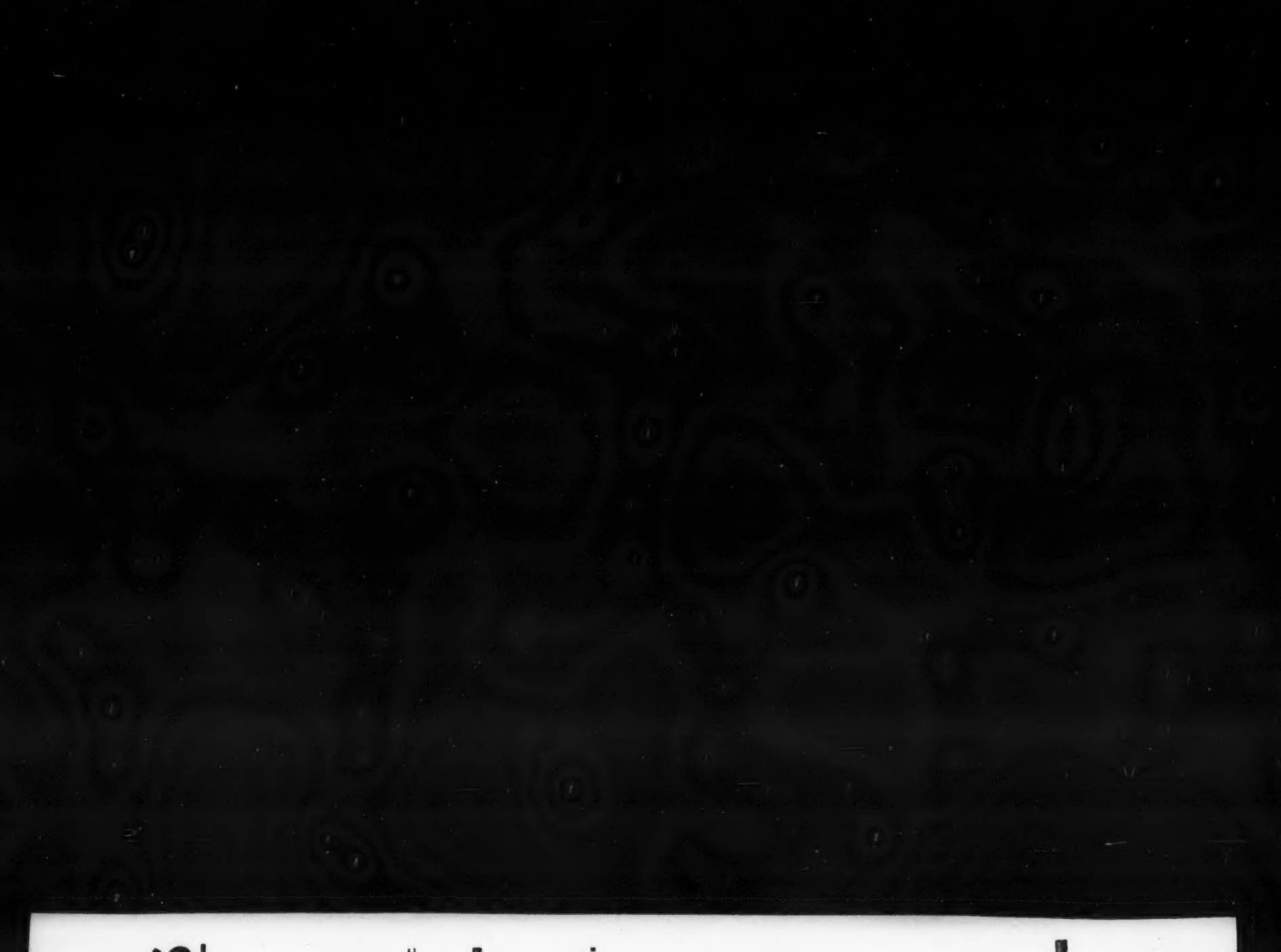

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WE INVITE PRACTICAL ARTICLES ON THE TRADE IN ALL ITS BRANCHES, WHICH WILL BE PAID FOR. MSS. SHOULD BE WRITTEN ON ONE SIDE OF THE PAPER ONLY.

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NOTES AND COMMENTS.

Possibilities of Malleable Cast-Iron.

We have no hesitation in claiming that the possibilities of malleable cast-iron as an engineering material, in competition with mild steel (forgings in some cases and castings in others), is very imperfectly appreciated. Why this should be so is not difficult to understand, for the "malleable" side of the iron-foundry trade has been the last to come out of its shell and allow itself to be talked about by engineers and other users. Discussing the subject of motor-car manufacture recently, Mr. L. H. Pomery, before the Institution of Automobile Engineers, remarked that the external finish of steel castings was a weakness in that class of work, and that malleable cast-iron certainly scored in that respect; when dealing with steel and malleable castings from the same pattern the two metals were quite easily identified. The chief complaints in regard to malleable-iron castings, he said, were occasional hard batches and perpetual delay in delivery; but its physical characteristics were very good, and there seemed no reason why it should not be a good material for road wheels and compete with steel castings all round.

The delay in the delivery of malleable-iron castings appears inseparably associated, in the minds of buyers, with orders for that material; and there is no doubt that delays are all too frequent and tend to divert orders to more readily obtainable material. Malleable-iron castings labour under the difficulty of requiring anything up to about 14 days for the complete process of production if Reaumur or European practice is followed, and somewhat less for the blackheart or American process; whereas steel castings can be delivered in two or three days from commencing the work. The trouble of hard batches and irregular results, however, is not inherent in the process, but arises merely from bad practice or poor materials. There is probably no metallurgical process in greater need of systematisation than the "malleable" process; for the vital change that forms the essence of the process may be checked or prevented by several causes that may not be obvious to even a very observant man. In the first place, the regulation of the composition of the iron is far more important than most small founders realise. There are certain limits within which the composition may vary without affecting the normal process of annealing or malleableising; but to trespass beyond those limits is to incur difficulty in completing the process without excessive temperature or time of annealing—if the process is completed at all. Yet there are numbers of malleable-iron founders who but rarely have their raw material analysed, preferring rather to rely on the name and reputation of a brand. As regards annealing ore, also, the vaguest idea of the composition and functions of the ore as a decarburising medium are held by many users, and it is no uncommon thing to find batches of work being spoiled and deliveries delayed by reason of annealing a high-sulphur iron in an ore which skins over the castings and, by thus sealing them in, prevents the very function which the ore is supposed to perform.

In some classes of founding the chemist may find little useful employment, but in the malleable-iron work of the future he must pay an important part, even if only as a periodical consultant to check the materials; and the scientific regulation of temperatures also must be accepted as an essential if the process is to compete with its rivals on a large scale.

We admit candidly that there are "malleable" men who can gauge the temperatures of annealing and control the process with an almost scientific accuracy; but that ability is the result of long experience and training which others who work at the trade have not been able to acquire. Malleable-iron founding will come to its own, but only by operating on comprehensive and systematic lines, controlled by those aids which almost every other metallurgical process has enlisted.

Casting Pure Copper.

The difficulty which has in the past been associated with the casting of pure copper lies in the fact that since the addition of any other metal, even in extremely small quantity, lowers the electrical conductivity, the use of the customary non-ferrous foundry deoxidisers is prohibited. Copper, as is well known, is difficult to cast pure, owing to oxidation and the inclusion or absorption of the oxide by the molten copper itself. This oxide can be removed by the addition of small quantities of silicon, magnesium, manganese, aluminium, phosphorus, zinc, and other metals, but almost inevitably some of the addition remains and impairs the conductivity of the copper. One maker of these castings recently claimed that he was obtaining 95 per cent. conductivity, using a copper-aluminium alloy as a deoxidiser, and that he never found more than a trace of aluminium remaining in the metal. If this is the case the results are certainly very good.

Magnesium, belonging to the same class of metals as aluminium, and also having a very strong affinity for oxygen, is another suitable deoxidiser for copper, subject to the same objection above mentioned. About 2 oz. of this metal is generally used to 100 lbs. of copper, and should be introduced into the molten metal by pushing it under the surface with tongs or other suitable appliance, then thoroughly stirring the whole. A good covering of charcoal is used to protect the metal from the atmosphere.

When silicon is used it is introduced in the form of silicon copper (Cu. 90—Si. 10), and about 1 lb. of the alloy is added to 100 lbs. of copper. In order to leave as little as possible of the additional or deoxidising metal in the copper to affect its conductivity, however, the amount should be proportioned to the extent of the copper oxidation—a difficult and almost impossible matter in the absence of analysis, unless careful experiments are made.

The affinity of boron for most elements except copper has led to the use of a boron compound as a deoxidiser for copper. Dr. E. Weintraub, of the West Lynn Research Laboratory of the General Electric Company, U.S.A., while experimenting on the production of pure boron, conceived this use for it, since boron appears to have no affinity for copper. He found that the addition of about 0.1 per cent. of amorphous boron or boron sub-oxide to copper gave a cast bar which had 94 per cent. conductivity of Matthiessen standard. A simplification of the process was to employ a boron flux instead of the true sub-oxide, as it was found that any material which contained boron in a state of oxidation below that of boric anhydride was suitable. Boron sub-oxide is produced by reducing boric anhydride with magnesium, aluminium, or an alkali metal, and chemically treating the reaction product. But for the purpose in question it is not necessary to treat the product, as the excess of boric anhydride and of magnesium borate outside of the boron sub-oxide is found to be useful in diluting the active agent boron, while at the same time not having any harmful effect on the copper. The use of 0.75 to 1.00 per cent. of this boron sub-oxide flux is equivalent to 0.08 to 0.10 per cent. of the boron sub-oxide.

Boron fluxes have since the time of Dr. Weintraub's discovery come into regular use, with admirable results, though the process does not yet appear to be commonly adopted. As regards the method of using the material, the flux can be added to the copper in different ways. The method in the Lynn Foundry is to mix half of the boron flux to be added with charcoal, put it on the bottom of the pot, and melt the copper. When the copper has reached the necessary temperature, the pot is taken out, the slag skimmed off, and the second half of the boron flux added and thoroughly stirred in. After a minute or so the slag comes up to the surface in the form of fused lumps and is skimmed off, and the melt is cooled down by adding gates or risers until the proper pouring temperature is obtained. When reverberatory furnaces are used, the procedure usually followed is to put the flux in the ladle pot on the bottom, pour the copper over it and stir thoroughly with a graphite stirrer. The flux is ground up into coarse grains and used as required to give the necessary boron content.

The best possible results are not obtained by the correct use of a deoxidiser alone, for the method of gating and running the casting is an influential factor. The density of the metal affects the electrical resistance, and hence to cast in such a way that the metal does not set thoroughly dense is to lower the conductivity. Hard-drawn copper has very high conductivity, on account of the closeness of its structure, and while the same denseness cannot be obtained by casting alone, a properly fed casting with a good head gives a much better result than one which is badly run. Possibly casting under mechanical pressure would give the desired result but 97 per cent. appears to be the highest obtained in ordinary practice, while in some classes of castings, and when using foundry scrap copper, it is not practicable to guarantee much more than 90 per cent. of conductivity.

MANUFACTURE OF CHARCOAL.—The Board of Agriculture has issued an interesting leaflet dealing with the manufacture of charcoal. It states:—"In consequence of the war the demand for charcoal, both for heating purposes and for ammunition, has already greatly increased, and it is probable that it will remain high as long as hostilities continue. There is no difficulty in manufacturing charcoal in kilns; the initial expenditure is small, and the amount of skilled labour required is not very great, while wood which might not otherwise be utilised is turned to account. It would be unwise, however, to attempt to make charcoal without some skilled labour, and, although it has been found possible in an emergency to employ 20 to 30 unskilled men under a skilled charcoal-burner and a good foreman, there are some operations which only a trained and experienced man can efficiently perform. Details are given of the site for the kiln, the covering and firing of the kiln, regulation of the burning, opening the kiln, and the yield of charcoal. With regard to financial return, the Board says that "In normal circumstances, charcoal in large consignments sells at from £2 to £2 10s. per ton on rail, while for small quantities (say, two or three tons), such as are used for drying hops in the South of England, as much as £4 per ton may be obtained. At the present time, however, prices are higher, and large quantities are being sold at from £3 10s. to £4 per ton on rail."

Training of Foundry Apprentices.

For some time a Special Committee of the British Foundrymen's Association has been conducting an enquiry into the conditions existing in the foundry trade of this country and the systems of apprentice training adopted. The terms of reference of the Committee are as follows:—

(*a*) To enquire into existing practices *re* employment of foundry apprentices and juvenile employés; (*b*) to obtain information on British and foreign apprenticeship systems; (*c*) to enquire how far those systems are applicable to British conditions; and (*d*) to formulate a scheme whereby a more effective system may be made common in British foundries and the standard of youths entering the trade be raised. Information on the subject to be solicited from foundry employers and managers and also from Trade Unions, the various grades of employés, and scientific and educational associations and authorities.

The First Report of the Committee has now been presented to the members. The recommendations put forward, however, are not to be regarded as definite and final, but rather as tentative, and with the object of eliciting information and criticism from the trade. We append abstracts from the report:—

On the evidence so far available the following general conclusions have been arrived at:—

(1) In the majority of foundries in Great Britain there exists no system of apprenticeship which ensures to the employers the service of the boy for any stated number of years and to the boy a systematic course of instruction in the various branches of the trade such as is requisite for producing a competent foundryman.

(2) The amount of instruction, experience and real training received and acquired by the boy in the course of foundry operations is dependent on the organisation of the shop, the class and variety of work produced, the character of the foreman or manager, and the character and mental acquisitiveness of the boy.

(3) Boys of much more varied character and ability enter the foundry trade than enter other branches of engineering. Shops which are badly equipped and where the conditions are not conducive to comfortable operation generally attract only a low grade of youth; while other shops appear to obtain a fair supply of really intelligent youths.

The Committee cannot wholly endorse the claim that the foundry attracts only a low grade of boys, for it appears that where the conditions are good and attention is paid to the training of the boys, many who at first seem dull and unintelligent develope into quite capable workers. This fact suggests that the age of 14 to 15 years, at which the majority of foundry lads start work, is a crucial period in their development, during which every endeavour should be made to encourage their mental development and train their intelligence. It also appears that excessive routine work during the first two or three years of operation in the foundry stunts the mental development of the boys and robs them of that interest in their occupation which is necessary as a stimulus to improvement.

(4) The elementary education of most of the boys is so imperfect and defective as to render class instruction in foundry technology and science extremely difficult; many of the boys appear to have benefitted little by the last few years of their schooling. In some cases this appears to result from a period of erratic employment as casual labour between leaving school and entering the trade; in other cases home conditions operate against the efficiency of the elementary schooling received by the boys.

(5) Even boys of poor elementary education can make considerable advancement in the trade under careful control and guidance, and when their interest in their calling is aroused it is less difficult to make good the deficiencies of elementary schooling and pass on to a higher grade of class instruction.

(6) The absence of any retention on the services of the boys, where no employment agreement or apprenticeship exists (as is generally the case), militates against the employer expending more time, attention and money on their instruction than is absolutely necessary for the work of the moment.

(7) The boy is at a serious disadvantage in learning his trade if he is bound, by agreement or otherwise, to serve in one foundry for a number of years, unless he is guaranteed a certain amount of instruction and variety of work. The organisation of some shops, however, does not readily allow the boy to obtain experience of a variety of work, and his instruction is consequently limited to a similar extent.

(8) Class instruction in the principles and practice of founding, and in elementary metallurgy as applied to founding, appears to be essential; but it should be preceded and accompanied by actual practical instruction in the work. Moreover, it cannot be effectively given until a fair standard of elementary education has been attained.

PRACTICAL INSTRUCTION.

Until further evidence has been taken and fuller information received regarding existing methods of conducting the practical training of young foundry employés, the Committee does not feel at liberty to offer definite suggestions as to what system or practice is the most desirable and effective. The considerations involved are too complex, and the variations in local conditions too great, for any rigid system to be applied universally.

As a general principle, however, it may be accepted that, subject to the efficient conduct of the foundry's operations, the boys should be placed at as great a variety of work as possible, and be instructed personally by a competent workman. The corollary of this is that a mutual agreement should exist between employer and youth which would prevent the latter leaving the service of the former until a fair period of service had been rendered in return for instruction given.

Any mutual acceptable form of agreement for training and service would probably be required to embody a proviso that the boy be allowed facilities for the class or outside instruction requisite for his proper training in the craft. What form these facilities should take, and whether they should include the allowance of time during working hours has not yet been decided. Some firms find it quite practicable to make such time allowance, without reduction of pay; but it is conceivable that under some conditions of operation such a scheme would not meet with employers' approval.

In proportioning the time to be allocated to the different branches of foundry work during the period of training, it must be remembered that foundry service is divided into several sections which are each more or less distinct. Coremaking in itself forms practically a distinct trade, and a competent coremaker may normally spend his life at the work without touching moulding or furnace work. The moulder, also, though he should understand the principles and production of cores, as a rule, does not actually require to make them, except in jobbing shops where the conditions sometimes necessitate the same man performing both operations. The working of the furnace, also, in a fair-sized foundry, is generally in the hands of one man entirely, and he does not require to be competent either as a core-maker or moulder. The foundry charge-hands and foreman,

however, require to know intimately each class of work. Hence, it is necessary for some at least of the boys who enter the trade to be well acquainted with all its aspects, and this can only be secured by experience at each branch of the work in turn. For this reason, such boys who display special aptitude and intelligence, both at their work and at the concurrent classes, should be given every practicable opportunity for widening their experience by being shifted from one class of work to another when competence at one has been attained. Probably most employers will endorse the claim that in many foundries this change of experience cannot be accorded to all the boys; but in nearly every case some variety of work can be given without serious detriment to the efficiency of the foundry as a profit-earning medium.

CURRICULUM FOR TECHNICAL INSTRUCTION IN CLASSES.

While any proposals ultimately put forward by this Committee will probably be tempered or modified by the final analyses of opinions received from foundry employers, the nature of the training which is desirable for all foundry apprentices can, and should be, determined as early as possible. When the nature of that training is established, the attainment of its application can be discussed with greater facility. The Committee has provisionally outlined a curriculum representing what may be termed the maximum scope of foundry instruction, leaving the application of all or part of this to a later stage of the enquiry.

As to the nature of the instruction which all foundry lads should receive, much of this, naturally, can only be learned by actual operation at the work, and may be accepted as distinct from class instruction. Of such a nature is instruction in the practical use and handling of tools, while mechanical skill also can only be so acquired. Other instruction involves both practice and principle, and while some knowledge of the latter may be acquired in classes, it is best given in association with the practice to which it relates. Other instruction, again, is purely theoretical or scientific, and while it has a direct relation to practice it cannot well be taught in the course of the working operations, either in works or classes, but is essentially subject-matter for class instruction.

Taking, then, the various subjects in question, they may be classified as follows:—

A.—Practical Instruction.—(Shop or masters' instruction.) The physical and mechanical operations involved in the use and manipulation of foundry tools and appliances. The handling of weights, materials, metals, etc. Methods of moulding and sand and loam core making.

B.—Practical and Theoretical Combined.—(Class instruction with reference to work actually in hand; possibly best conducted in practical classes.) The general principles of mould construction, venting, etc. The treatment and handling of sands for different work. The specific distinctions between green-sand, dry-sand, and loam moulding from a commercial and practical standpoint. Different classes of moulding as applied to different work; advantages and disadvantages; and machine moulding and its possibilities. The effects of mould design on strength of moulds and ultimate castings. Principles of cupola construction and operation, lining, charging, repairing, blast, tapping, fuel consumption, etc., pouring temperatures, rate of cooling, chilling, etc.

C.—Purely Theoretical and Scientific. (Class instruction.) Elementary inorganic chemistry embracing the periodic law, affinities of elements, chemical compounds, solutions, mixtures, etc. Elementary metallurgy; nature of alloys; effects of temperature and cooling on constitution. Fuel combustion and its phenomena. Nature of fuels and requisite properties of suitable foundry fuels. Mixing of metals by composition. Significance of fracture. Micrography. Sands, their chemical constitution and nature, and properties under heat. Physical and chemical conditions as affecting casting of metals. Strength of materials and suitability of materials for work. Calculation of weights of castings. Arithmetic and elementary mathematics, applied to weighting of moulds and to other foundry considerations. The reading of working drawings. Setting out of work from drawings, etc.

In addition to the foregoing, the more advanced pupils should receive instruction in shop organisation and costing, estimating, etc.

Since the existing technical instruction suitable for foundry apprentices is extremely meagre, being mostly confined to classes in metallurgy, and these often as only part of some other course of instruction, a movement for foundry technical instruction must be accompanied by the provision of much increased facilities in the way of suitable classes widely distributed. These classes may be provided in two ways:—(1). By the Education Authorities as continuation classes in elementary schools or technical colleges or other institutions. (2). By the support of combinations of employers of foundry labour, the classes being organised and controlled by a suitably-appointed authority. Probably the utilisation of the existing educational machinery would prove the more satisfactory.

DISTRIBUTION OF CLASS INSTRUCTION.

If it be accepted that class instruction is necessary in the training of a young foundryman, it follows that such training requires to cover definite ground so as to avoid undue overlapping with practical or works training and afford the maximum of such instruction as cannot well be given in the shop. With this in view the Committee has drafted provisionally a scheme for the distribution of class instruction, covering those sections enumerated previously as "*B.—Practical and Theoretical Combinded,*" and "*C.—Purely Theoretical and Scientific.*" The latter essentially should form part of the training during the latter years of pupilage, but to some extent comes within the scope of early class instruction.

1st Year Class.—This should commence with simple descriptions of the elements of moulding practice, with practical demonstrations of the production of simple moulds with and without cores. The pupils should also perform the operations of moulding and coremaking. Where possible the pouring of the mould with molten metal should be included; the metal being for demonstration purposes only, might be lead or any easily-melted metal or alloy. Whenever possible the pupils should themselves perform the operations, rather than be merely told how to do so, though a demonstration by the instructor would generally be essential.

The practice and object of venting should be carefully explained in the preliminary stages of class instruction and be reiterated later in connection with the properties of various sands.

The principles underlying respectively green-sand, dry-sand and loam work should be explained, and work in each performed during the year, attention being confined to the simple class of moulds.

Green-sand, dry-sand and loam cores in their respective uses should be dealt with, and the nature and possibilities of each explained and demonstrated.

During the latter half of the first year the pupil should be introduced to an elementary course of metallurgy, but only sufficient to give a general idea of the processes of producing metals from their ores, the broad distinctions between and characteristics of various classes of pig-iron and the elements comprising them. The quantitative effect of composition, however, should not be dealt with except in a general way. The general properties of refractory materials also should be dealt with.

2nd Year Class.—During this (and also the first year) the pupil should be encouraged to remedy

those defects in his elementary education (knowledge of the English language, simple arithmetic and decimals) which militate against his further instruction.

This is essentially a matter for individual consideration, since the state of advancement of probably each boy in a class will be different.

The second year's instruction should follow the same lines as that during the first year, but taking more advanced work in practical moulding and core-making. A definite course of instruction in elementary inorganic chemistry should be started, dealing with the elements, the periodic law (explained graphically), combinations of elements as mixtures, solutions and chemical combinations, and the effect of affinities of elements in altering the constitution of materials. A fuller explanation could be given at this point of the generation and presence of gases in moulds, and further treatment of the practice of venting, moulding, running and gating to deal with mould gases.

3rd Year Class.—During this year advanced moulding practice should be taught, and would probably not require much practical work, but instead blackboard diagrams, etc. The principles of pattern construction should be outlined and the defects of various patterns discussed. The metallurgical side of the pupils' instruction should cover the composition of iron and non-ferrous alloys, their constitution and physical characteristics, methods of testing, etc., and the effect of temperature of casting and reheating on the physical properties of metals and alloys; the composition and physical properties of cokes for furnace work, the microscopic examination of metals, setting out of work from drawings, and arithmetic applied to foundry matters.

4th and 5th Years.—These classes should be conducted with a view to the instruction of charge hands and foremen, and should include more advanced metallurgy, the theory of furnace construction and operation, refractory materials, the testing of sands and materials, shop organisation and costing, and any other matters which can be included in the time available.

DISCUSSION AT FOUNDRYMEN'S ANNUAL MEETING.

At the Annual Meeting of the British Foundrymen's Association in London last month, this Report was informally discussed on a motion according a vote of thanks to the Secretary of the Committee.

Mr. F. J. Cook, in proposing the vote of thanks, said that this question of training apprentices was one that had not been jumped at either by education authorities or foundrymen themselves. It would have to come about by a very slow process of convincing people and by constantly talking about the benefits to be derived from education. The Committee's Secretary was to be congratulated upon the way in which he had put at least one portion of the work before the Association, *i.e.*, the directions in which the educational authorities could help in educating the foundry apprentice, and he would like to suggest that authority be given to circularise all the educational committees in the country who were likely to be taking up this work of the technical training of foundry apprentices. This circular should call attention to what the Association had in view and what its aims were, and point out what was suggested as the course for apprentices. No matter how well the syllabus was drawn up, they would not get education authorities to jump at it and put it into working order. Therefore, it was necessary to start at once and let the authorities know their ideas.

Mr. S. A. Gimson seconded the vote of thanks. The report, as yet, was not final; it only showed how far the Committee had got up to the present time, and he thought there were at any rate useful suggestions in the report. It was hoped that the members of the Association would consider the report, and let the Committee have all their criticisms and suggestions upon it in written communications. It was to be hoped that the Committee would continue in existence, and would present a further and fuller report in which something more definite would be put forward. The present report was tentative, but there were valuable suggestions in it, and the further suggestion of Mr. Cook as to sending a letter to all educational committees was another valuable one. He himself was on one educational committee and on the technical school committee also, and he knew that these committees very often did not know anything whatever as to the subjects they ought to be teaching, and if there were bodies of people up and down the country to whom they could refer as to the best ways of teaching certain subjects it would help not only the committee, but the staff of the particular educational institution.

The President said he must add his tribute to the great progress that was being made in connection with the foundry apprentice. The Committee had given them all a lead in Scotland, where the matter had been taken thoroughly in hand by the Employers' Association, and the whole thing was cut and dried, although a definite scheme had not been finally passed. When it became known what was going to be done he was sure it would stagger some of the old stagers, whilst the new and more progressive men would be pleased. One of the most important things was an important advance in the wages of the foundry apprentice with a view to getting the right men. At present he was sorry to say they were only getting the weeds, and the prestige and progress of the foundry trade was being materially interfered with by the class of men now being obtained for making into moulders. The scheme in question in Scotland was left in the hands of three men for a decision, and each one was fully in favour of it, so that there was every chance of it being adopted.

Mr. Jones said he was very pleased to hear of the suggested advance in apprentice wages in Scottish foundries. For some years the boys with whom he came into contact were paid very low wages, but he had been interested in the problem during the past eight or ten years, and they had been given an advance. The boys were now paid very good wages, and they appreciated the rise which was given them every six months. He also paid for their schooling if they went to a night school, and if they went to a college he also paid for that, and he also bought all books. He took care to see that they were in a fit and proper condition to go to the night school, and was convinced that he would be repaid in time.

The President: I am sure you will.

Mr. Gimson said there was one point employers should remember; it had arisen in Leicester and no doubt elsewhere, and that was that the boys who go to night school should be allowed time off. Classes should either be arranged in the afternoon, or, if the boys had to go to school at night, some compensating arrangement should be made by which they should not be expected to spend such long hours at the works. In Leicester they were gradually getting this recognised in different trades and partly in the engineering trade, and in the end the principle would have to be extended over the whole of the country, viz., that on the days the boys went to night school there would be a little easing of the daily work.

Mr. B. F. Sperring said that at Portsmouth the Employers' Association of the iron trades had recently offered a scholarship to the two top boys pre-

pared by the municipal school, so that they could go from the municipal school to the grammar school.

Mr. M. Riddell associated himself with all the remarks made concerning the work of the Committee in this matter. It had done a great deal in advancing the prestige of the Foundrymen's Association, especially amongst employers. If all employers could receive the pamphlet which had been prepared they would realise that the Association was no ornamental society, but one meant for serious work. If employers were made to realise that there were men ready to do this work it would aid immensely in getting the right men in the industry.

Mr. A. R. Bartlett (Erith) said there was a technical institute in his district, but it had been found very difficult to get any boy to attend. For five or six years there had been a moulders' class included in the prospectus, but last year was the only year they had been able to induce any foundry boys to take up the subject. It was decided that if 10 boys would take up the subject the class would go on. By a great effort he got one boy out of his foundry to go, and to make the class up they had to go to the neighbouring town of Dartford. The manager of a firm there thought it was a grand idea, and persuaded his firm to pay the whole of the expenses, including railway fares, of the other nine to keep the class going. In the Erith district there was a lot of boys, and some means of interesting them was wanted. Not only did the employers need to be impressed with the value of it, but the boys also wanted to be impressed tnat it was something to their advantage. This seemed a most difficult thing to do.

Mr. J. W. Worrall thought that if a boy took up technical work he should be granted a bonus if he attended a night school say three months in the year. He adopted this system. Similarly, he refused to give rises to those boys who did not attend night school, and the system worked well.

Mr. Bartlett said that at Erith four or five years ago the late President of the London Branch, Mr. Horne, metallurgist at Fraser & Chalmers, was appointed educational superintendent to the firm, and he used every endeavour to induce the boys to go to evening classes. If a boy came into the shop it was definitely stated that he would be expected to go to classes, but even with that pressure the boy did not go, or he went only part of the time and was not at all enthusiastic, and finally left the classes. The boys who entered the foundry trade were usually not sons of foundrymen. The general run of moulders did not desire their boys to be moulders; they knew the evils attending the work, and they generally looked for something softer and cleaner. In many places the boys were agricultural labourers' sons, and these boys did not get the necessary education in the elementary school to fit them to go to the night schools. Generally speaking, the foundry got the scum, and when a teacher did not know what to do with a boy he sent him to the foundry. Therefore, some ways and means were necessary to get these boys to take an interest in their future welfare.

Mr. T. H. Firth thought the suggestion of giving the boys more money would be a big inducement towards getting the right class. His firm gave as an inducement to boys attending night classes 1s. a week extra for each first pass, in addition to paying the fees, and 6d. for each second. He had some boys who got five firsts last year, and they got 5s. a week more for the year; whilst if the boy only got five seconds he got 2s. 6d. a week more than the boy who did not attend the classes. He though' 'his would get over some of the difficulty.

Mr. W. H. Aston quite approved of employers paying fees and increasing wages, but, in addition, it was essential to make the lessons attractive. That was needed as much as anything.

Mr. Willis, in supporting the vote of thanks, agreed with the President that the boys should have more money. The difficulty was to get the right class of boy. Hitherto the foundry trade had been looked upon as the reservoir for the dregs. The Association existed for the very purpose of altering that, and it was doing good work in improving the status of the founder. Probably more would be done in that way than in technical education at present. The boys at present obtained were not fit for technical education, and it was scarcely ever that they took an interest in evening classes. The foundry had been looked upon as the bottom rung—as, indeed, it was—of the engineering industry, but it was regarded as the place to shunt all the lads who were no good for anything, and no better result would be obtained until that slur was removed. Happily, people were beginning to realise that the foundry could be made something superior, and the Committee's ideas of the education of the boys would come out right eventually. The first thing was for employers and firms to raise the status of the foundry from the standpoint of making it more comfortable and clean and a more desirable place to work in, which it very often was not at present. Then a better class of boy would be obtained who would appreciate instruction.

Mr. D. Gordon said that in London there were scholarships, but the number taken up was not very great. He also made reference to the questionable practice of swelling the supposed foundry classes by getting pattern-makers' apprentices to enter for the scholarships of £3 a year for three years with everything free except any instruments that were necessary. Mr. Aston had raised the question of making the class interesting, but what was one man's meat was another man's poison. It would be rather nice to know how to make the classes more interesting. He did not know how it could be done. There was dry reading in a technical class, and a certain amount of latitude must be allowed. The payment of extra wages was a good idea, but the manager of a foundry studied his own interests first. Suppose he wanted a boy to stay overtime to skim, and the boy said he wanted to go to a class; the manager said "skim," and the boy skimmed. Then on going to the class, say at 8.30 p.m., the boy was tired out before he got there, and it was a hopeless job to try and teach him. If the "sandwich" system could be adopted it would be a good thing, but personally he did not hope for it, because the average employer was out "on the make." Perhaps a way out would be to allow the boy off in the evenings, or when he went to a class to allow him a quarter the next morning.

Mr. Cook: That is done.

Mr. Gordon agreed, but said it was not done everywhere, and that was the difficulty. To get the whole problem on a basis was a very difficult matter. The Committee's Secretary, in tackling it, had plenty of confidence; more than he (the speaker) had.

The Secretary of the Apprentice Training Committee (Mr. Alexander Hayes), in replying, said he thought it was quite invidious for Mr. Cook and the other gentlemen to have singled him out for an expression of thanks. For he was only one of about 100 in the Association who had contributed to this work. The fact that he happened to be in an official capacity had nothing whatever to do with it. At the same time, if he could take the vote as a personal matter he thanked them for it as an approval of the work. They were only at the beginning of the work

yet, and it would take very much larger proportions than many members appeared to understand or expect. The Committee would put forward very bold schemes, and, if possible, carry them through, and the suggestions made would probably cut right across the lines of precedent or existing conditions, simply in order to create what were regarded to be the desirable new conditions for the foundry trade. In commencing this enquiry the Committee found themselves faced with the difficulty that opinions were so various and the conditions were so varied that all they could do was to put forward tentative suggestions to see how they met existing conditions—to get opinions rather than to offer advice to the trade. The pamphlet which had been prepared was put forward not as formal suggestions, although it might convey that impression. It was put forward to invite criticism, and it would trouble neither him nor the Committee in the slightest if every paragraph of the report had to be entirely revised from top to bottom, because it would mean that they had aroused an interest in the trade which would enable employers, apprentices, and their parents to realise the possibilities of it. He definitely associated himself—and very forcibly—with the opinions expressed by Mr. Gimson to the effect that evening classes without some relief from the pressure of day work were not desirable. He personally stood very definitely for day classes during the first few years—classes during working hours. He knew he would meet with strong disapproval by probably half the members—perhaps the majority of the members present and in the Association—but he thought they would gradually come to see the advisability of sacrificing a little for what they would get for a proper system of educating the trade. If they singled out any section of this work and attempted to apply improvements, it was very much like ploughing the sands, because the good done in one direction would be lost in another. But if the problem as a whole were tackled and a comprehensive scheme developed good results would ensue. Many men had attempted to create new conditions and had failed simply because they placed themselves at a disadvantage in ordinary commercial competition. Little men could not afford to do it, and unfortunately from this point of view it was the little men who were often the best trainers of juvenile labour. Unfortunately, however, these men were placed at a disadvantage in making sacrifices by the competition of other firms of better financial standing. If a generally recognised system could be introduced which would allow the question to be treated on common-sense lines, that disadvantage would be eliminated and would enable all employers to be placed on the same basis. In the London district, with the kind co-operation of several technical institutions and various members of the Association, an endeavour was being made to start a movement somewhat on these lines; to get a section of those employers who thought they could afford to make the experiment to sort out their boys and send them, even if only one at a time, to suitably organised classes for two years. To commence with, those classes should be in the day time to meet the restrictions of the L.C.C. as to junior students, and also to overcome the difficulty Mr. Gordon raised, of the boy being unfit for study at night after a heavy day's work. The classes should be at, say, 3.15 p.m., so that the boy could get an interesting and instructive lesson, practical where possible, in the basic principles of his operations, followed by a short interval and a brief interesting lecture by some competent man—and there were many—on the more scientific or technical side. If employers could be prevailed upon to make that, not an evening class or an arduous task to be carried out after the day's work, but part of the day's training, he thought, the employer would benefit as well as the boy. How far they would succeed he did not know, but the technical institutes seemed eager to do all they could to help. All that would be at first necessary would be sufficient in the way of practical implements and appliances to allow first-class instruction in the rudiments of each department. At present a boy only learned one section of the trade, and until he possessed the rudiments of the remaining departments he would not make much progress. If the British Foundrymen's Association was worthy of anything it ought at least to come to a decision and act on that most important matter. He would like to solicit criticism and suggestions, and he would also like the members to remember that they might be able to give the committee an insight into conditions which were entirely foreign to the survey already undertaken. The committee had a lot of work before it and he hoped the work which had been undertaken by the Branches—and which he would like to take this opportunity of very cordially acknowledging—would be carried on a little more energetically, perhaps, on the same lines. Two or three Branches had lent very considerable assistance, and it was to their efforts and those of the members of the Committee collectively, that the members ought to have given the vote of thanks which they had so kindly accorded to himself.

The proceedings then terminated.

CASTING BABBITT BEARING IN PERMANENT MOULDS.—At a recent meeting of the London Branch of the British Foundrymen's Association, Mr. H. G. Barrett described the casting of half babbitt bearings in a cast-iron mould. The bearings were ½ in. thick, 20 in. diameter, and 16 in. wide. The concave part of the mould was separate from the convex part. The former was filled with hot coke, and the latter part lowered on to it. After being made hot (not a red heat) it was dressed with dry plumbago. The lead and tin were melted in a crucible kept for that purpose, the antimony was melted separately, and poured into the lead and tin after they were out of the fire, and the whole was stirred with a piece of wood. The temperature was kept as near as possible, so that the whole alloy was in colour a very dull red; it was then poured into the mould in a steady stream (the metal used was new and not babbitt that had been alloyed before). This gave very successful results. In some practical suggestions on the pouring of babbitt metals the Syracuse Smelting Works, Brooklyn, N.Y., U.S.A., remark that it is of utmost importance to pour babbitt metals at low temperature, as a metal poured at high heat will be brittle and open-grained. The cast liner will be tougher and denser in proportion to the reduction in heat. When practical, also, the chill should be taken off the mandrel and shell by warming, as this will dry off the moisture which causes blowholes and also make the metal flow better. As to the remelting of metals, it is stated that instructions are generally given to stir before pouring; but those who give these instructions intelligently do so because the tendency is to pour metals too hot and the stirring lowers the heat. Many engineers have the idea that the purpose of stirring is to reunite the separated alloy. To determine whether the melted metal needs cleaning, its surface should be examined while it is at a fair pouring heat. If fine spider-web lines appear on the surface after skimming, the metal is clean. Casters often do not appear to understand that a high temperature of pouring Babbitt metal and consequent slow cooling, allows the formation of large crystals of the hard compounds, and gives a less serviceable bearing.

Continuous Casting of Rods.

A machine that dispenses with the present method of making rods of lead, zinc, brass, copper and aluminium by rolling, has been invented by Mr. Grenville Mellen and developed by the Continuous Casting Corporation, of Newark, N.J., U.S.A. The apparatus is described in a Paper prepared for the September meeting of the American Institute of Mining Engineers, by Mr. R. C. Patterson, Junr. It is a small continuous casting machine which produces the rod in one operation. The hot liquid metal is transferred from the melting crucibles directly into an endless chain of mould blocks in the machine, where

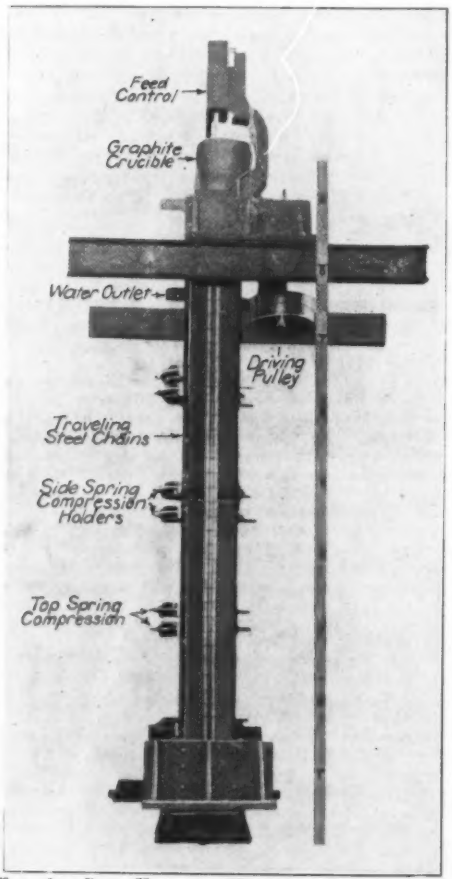

FIG. 1.—SIDE VIEW OF VERTICAL TYPE OF ROD-CASTING MACHINE.

solidification takes place, and the rod comes out continuously in a solid form at one end as long as the molten metal is supplied. The operation of these mould blocks so as to produce a solid rod of uniform structure constitutes an important part of the invention.

The vertical type of the apparatus is shown in Fig. 1. It is 12 ft. high over all, 2 by 3 ft. in horizontal cross-sectional area, and 6,000 lbs. in weight. The framework is of cast iron, and holds in position two endless chains of mould blocks, which are made in sections and meet on the centre line. The rod mould is made up of these jointed steel mould sections, into which the liquid metal flows. Each block is carried on four rollers which guide the chain around the end sprockets and carry it in its course through the machine.

The accuracy of alignment requisite to the production of a perfect rod in the mould groove formed by these sections is secured by careful machine work, and by building the four ways, down which the chains pass, so that two of the sides are fixed permanently, while the opposite sides are held to their position by spring pressure. The guides which carry the moulds while in casting position are water-cooled square tubes.

The length of this machine is somewhat indeterminate. A certain amount of both time and cooling surface is required to solidify the metal in the mould;

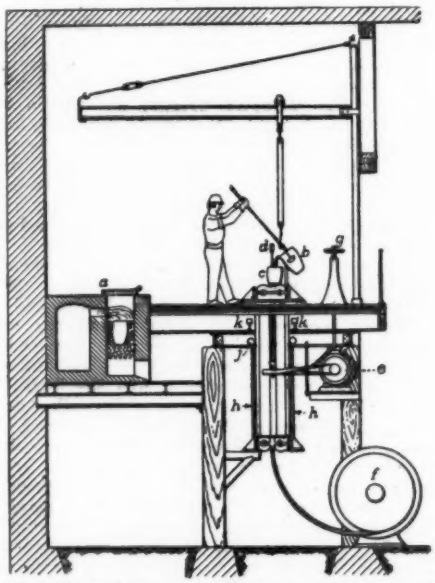

FIG. 2.—CROSS-SECTIONAL VIEW OF A CASTING SHOP USING VERTICAL TYPE OF ROD-CASTING MACHINE.

and one may use either a long moulding chain and run it fast, or shorter chain and run it correspondingly slower. The users have found that with 8 ft. length between centres for the chains a casting speed of 25 ft. per minute for ¼-in. brass rod does not cause the moulding blocks to rise in temperature above 450 deg. Fahr. When casting bronze mixtures, the moulding blocks should have about six times as much sectional area as the cast rod, to allow a reasonable temperature difference for the rapid removal of heat.

The first machines designed for this casting process were vertical; but experiments were later made with a machine working horizontally. The successful operation in a horizontal position, however, required more skill than that of an ordinary

labourer, and finally the vertical position was re-adopted. In this form one labourer, with a little preliminary instruction, can manage the machine without difficulty. Among the chief hindrances to horizontal operation were the difficulty of completely filling the moulds, and the fact that the lower chain did the greater part of the work and became, after a time, excessively heated, while the upper chain remained relatively cool. This caused an irregular structure both in the cast rod and in the drawn product resulting therefrom: and as a result the required strength tests were not satisfactory.* In the vertical arrangement the metal completely filled the mould, with uniform contact all around, thus causing each portion of the chain to do its work, and giving a symmetrical structure to both rod and resulting wire.

The vertical arrangement, however, necessitates operation on two levels, as shown in Fig. 2. The flow of metal into the machine is controlled by an electrically-operated automatic device, which adjusts the feed to the speed at which the machine is operated. If for any reason the machine should stop, the flow is automatically shut off. A safety device is incorporated in the drive, so that if any foreign material clogs the chain a safety pin is sheared, thus protecting the mechanism from injury. horizontally. Also, the horsepower is slightly decreased, and the machine is a few feet longer.

The continuous casting machine is also applicable to the production of aluminium and zinc rod. Aluminium rods are produced with diameters ranging from ⅜ in. upward.

Fig. 2 shows the casting-shop arrangement for a vertical apparatus. A long line of melting furnaces supply metal to one casting machine. The melting furnace *a* is one of 40, the crucibles of which have a capacity of 220 lbs. each with six heats per 10 hours. All of these are considered just sufficient, when operating at full capacity, to satisfy one casting machine in 10 hours. The feed basin *c* consists of a graphite crucible and has a capacity of 194 lbs. The automatic feed-control device *d* consists of a solenoid magnet operating in a battery circuit, one terminal of which is grounded on the machine and the other terminal attached to a graphite point projecting into the mould orifice. When the metal in the mould rises to this graphite terminal it closes this circuit and the magnet is energised. This magnet operates upon a beam to partly close a carbon valve controlling the inlet of metal into the mould bore. When the rod that is being cast is carried below this graphite tip, the circuit is broken and the valve lifts, allowing more metal to enter the machine. The

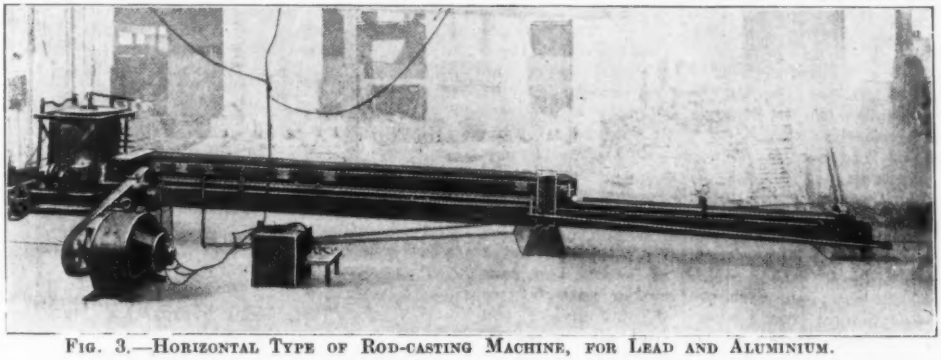

FIG. 3.—HORIZONTAL TYPE OF ROD-CASTING MACHINE, FOR LEAD AND ALUMINIUM.

The rods are delivered from the machine immediately to the die of the bull block, where they are drawn down to suit particular orders.

This new method of manufacturing rods does away with the following steps of the old system:—Casting the wire bar; handling the wire bar from the moulds: rehandling the wire bar to and from the reheating furnace; reheating the wire bar; rolling the wire bar. It also eliminates the loss from oxide scaling during heating and rolling. The power required to run the casting machine is only about 5 h.p., and the cost of large engines, boilers, coal bins, etc., is practically done away with. Another advantage is the elimination of danger to human life. The apparatus is completely enclosed, so that the operator is protected from injury. Finally, the labour cost of the process is claimed to be only 5 per cent. of that of the old method, the caster being the only workman required.

A later development of this continuous casting machine is the machine, shown in Fig. 3, casting rods of lead and soft-metal alloys, ¼ in. and upward in diameter. This is the first step in the manufacture of shrapnel bullets; and the machine will cast per hour enough lead rod for more than 200,000 bullets. The motive power required is from 2 to 3 h.p. This lead machine is practically the same as that used for brass, with the exception that it is operated variable-speed motor *e* is used to drive the machine The variation in speed is necessary to enable the machine to be operated on different brass mixtures, some of which flow more freely than others. This speed is suitably adjusted by the operator at the speed-control wheel *g*.

The reeling device *f* takes the rod delivered from the machine and rolls it into bundles. The cooling water jets *h* are arranged opposite the faces of the returning moulds through which a series of streams of water are played directly upon the mould faces when the latter have reached a temperature sufficient to vapourise this water. In practice the moulds appear perfectly dry a few inches above the uppermost jet. Above these water jets are steel mould-cleaning brushes *j*, which revolve by a chain mechanism and serve to clean any deposit from the surface of the mould and prepare it to receive the necessary facing which is applied in liquid form by means of air brushes *k*. The machine is patented in the United States and foreign countries.

J. R. Richardson, Baskerville Place, Broad Street, Birmingham.—A catalogue of engineering specialities, including blowers and exhausters, compressors, foundry equipment of all sorts, and other works plant has been received from this firm.

Free Carbon in Cast Iron.*

By J. E. Hurst.

The importance of free carbon and its influence on the properties of cast iron has long been realised by many ironfounders and metallurgists, but at the same time there are many to whom graphite occupies a minor position in consideration as to mechanical properties. However, in this connection one need only quote the words of Dr. Stead, who recently remarked that it was clear that graphite, so far as the strength of cast iron is concerned, was an enemy to the ironfounder; for, as was not generally known, the diminution of 0.1 per cent. Gr. C. below 3.2 per cent. down to 2.0 per cent. was coincident with an increase in the tranverse strength of approximately 2 cwts. on the standard bar 36 in. by 2 in. by 1 in., and 0.8 tons per square inch in the tenacity, the other constituents being approximately constant.

The study of free carbon is far from being exhausted, and in days when Diesel and Gnome engine cylinders are in great demand, the necessity for the study of free carbon and its influence on other properties becomes of double importance. The manner in which free carbon is formed is still to some extent a matter of doubt—or rather the details of the manner of precipitation of the free carbon.

Reference to the well-known equilibrium diagram of the iron-carbon alloys will show the mode of formation of free carbon as accepted at the present time. Successive additions of carbon gradually decrease the freezing point until it reaches a minimum value, at which the percentage of carbon is 4.3 per cent. This particular alloy of iron and carbon or eutectic consists of 50 per cent. of a solid solution of carbon in iron, or rather carbide of iron in iron containing 1.8 per cent. carbon, together with 50 per cent. of carbide of iron, a chemical compound of iron and carbon, and known micrographically as cementite, the solid solution being known as austenite.

At this point the formation of the first type of free carbon might well be explained. The amount of carbon absorbed by iron depends first on the temperature, secondly on the time, and thirdly on the pressure. Under normal conditions the effect of pressure is practically constant, and therefore negligible. Cast iron at a temperature of, say, 1,400 deg. C. absorbs 6 per cent., and in contact with carbon will contain more carbon than the same iron at 1,100 deg. C.; that is to say, the first is supersaturated. On cooling, this excess of carbon is gradually thrown out of solution, rising to the surface, and resulting in the formation of "kish."

Fig. 1 shows the cycle of changes which takes place in the solid iron on cooling. It will be seen that the cementite or iron carbide persists throughout the cooling, whereas the solid solution gradually changes into pearlite.

It is now generally accepted that the graphite present in cast-iron is formed by the decomposition of the free carbide of iron, cementite, during the solidification period. This cementite is not a stable phase, but always has a tendency to decompose into free ferrite or pure iron and free carbon, and for this reason is known as a meta-stable phase. The extent to which this decomposition takes place is a function of time, temperature, and pressure, and it will therefore be evident that the amount of free carbon formed during the solidification range is largely a function of the rate of cooling. The solid solution, austenite, will be seen to be responsible for the pearlite formed in the lower range of cooling through the stage martensite.

The presence of other elements either assists or retards this cycle of changes. The chief of these elements is silicon, the influence of which is so well known that it will only be necessary to just touch on the mechanism of its action. The first reaction of silicon is to reduce the percentage of total carbon, or, strictly speaking, to reduce the percentage of carbon in the eutectic. Fig. 1† shows graphically the manner in which this reduction takes place, *i.e.*, by using up a portion of the iron to form the chemical compound iron silicide Fe_2Si. The second and most important action of the silicon is that it assists in the precipitation of the free carbon. The manner in which this

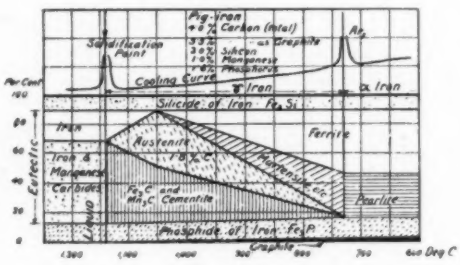

FIG. 1.

precipitation takes place is not correctly understood, but in all probability the following approximately represents the conditions:—During the solidification range the silicon remains dissolved in the solid solution austenite; the decomposition of the free carbide being completed by this silicon, which diffuses from the austenite into the cementite, with a result that in the final iron silicon is found both in the ferrite and pearlite in amounts depending largely on the extent to which this diffusion has taken place. The influences of manganese, sulphur, and phosphorus are too well known to need recapitulating here.

As far as is at present known, the only forms of free carbon met with in cast iron are graphite and amorphous carbon. The chief difference between these two forms is that graphite is a crystallising variety and amorphous carbon is a non-crystalline variety; while further, graphite possesses the property of marking paper. Perhaps the most important difference between graphite and the other varieties of carbon, however, is in its behaviour on treatment with strongly oxidising mixtures, known as the Brodie test. On subjecting graphite to prolonged treatment with a boiling mixture of fuming nitric acid and

* Abstract of Paper read before the Lancashire Branch of the British Foundrymen's Association.

† J. E. Fletcher, "Proceedings" Staffordshire Iron and Steel Institute, March, 1914.

potassium chlorate, it is converted into a greenish-coloured crystalline substance known as "graphitic acid," whereas amorphous carbon is perfectly soluble in the mixture. The green compound is a compound of carbon, hydrogen and oxygen of uncertain composition, and this affords a means of separating graphite and amorphous carbon. Arsem defined graphite as that allotropic form of carbon whose specific gravity ranges from 2.25 to 2.26. "The other varieties of carbon which have some of the physical properties of graphite . . . . but of a lower specific gravity, may perhaps be regarded as impure graphites; that is to say, mixtures of graphite with other forms of carbon."

To return to the occurrence of amorphous carbon in cast iron. This form of carbon is most commonly met with in annealed cast iron, and a better term for this amorphous carbon would be annealing carbon, which is defined by the Nomenclature Committee of the Iron and Steel Institute, 1902, as "the apparently amorphous, finely divided carbon having some graphitic properties, which separates from white cast iron during prolonged annealing."

The reaction involved in changing white iron to malleable cast iron by annealing is to some extent analogous to the formation of the graphite during the solidification of the higher silicon-content cast irons, the action of heat being to decompose the free carbide. The exact details of the manner in which this decomposition of free carbide (cementite) takes place involves complex theoretical considerations into which it will not be necessary to enter here. However, an interesting analogy can be made which brings out the influence of the two forms of free carbon in a very clear manner. A typical specimen of malleable cast iron (exhibited) gives a tensile strength of 20 tons per sq. in., and a bending angle of 90 deg. Microscopically, it almost wholly consists of ferrite (pure iron) and annealing carbon. A piece of cast iron consisting almost wholly of ferrite and graphite plates (also exhibited) has a tensile strength of 10.5 tons per sq. in., and bending angle practically nil. It will be quite evident that should annealing carbon and amorphous carbon be identical, from the point of view of mechanical strength it would be advantageous to have amorphous carbon present in normal cast iron. However, in the first place, it is very uncertain whether annealing carbon and amorphous carbon are one and the same thing. It has been suggested that the so-called annealing carbon might be a carbide of iron which up to the present has not been identified, simply because all attempts to separate it result in the decomposition of the carbide depositing amorphous carbon. The great trouble in this connection is that there is no definite means of identifying annealing carbon. However, in the light of the author's experience, it would seem that annealing carbon and amorphous carbon are identical. A peculiar property possessed by annealing carbon is that on heating to 950 deg. C. a specimen containing this form of carbon and then quenching, the free annealing carbon recombines with the iron, an extremely hard and unfilable specimen being the result. Before the Iron and Steel Institute in 1906 Dr. W. H. Hatfield gave a series of tests on cast irons, the results of which are shown in the following table:—

State.	Graphite.	Comb. Car.	Silicon
As cast	2.4	0.8	2.5
Annealed	3.24	0.05	2.5
Hardened	1.65	1.60	2.5
Tempered	1.65	1.60	2.5

Heating and quenching ordinary cast irons causes a portion of the free carbon to be reabsorbed by the iron, resulting in a hard, unfilable metal. This reaction is identical with the reaction of annealing carbon, and Dr. Hatfield considers that in all cast irons there is to some extent a certain amount of annealing carbon. Here is one explanation for many of the mysterious variations in mechanical tests.

Mention might here be made of the explanation of these variable mechanical tests so often noted, *i.e.*, that they are due to the presence of a network arrangement of phosphide eutectic and cementite. This subject has been ably discussed and expounded by Mr. F. J. Cook. In the first place, it must be remembered that it is not the network structure itself and the components of this network that are responsible for this increase in tenacity, but rather the network is a sort of indicator of some definite form, shape, size, or arrangement of the constituents which freeze previously, the chief of these being the graphite.

However, it must here be pointed out that I have not met any irons giving high tensile strengths and yet not showing a network arrangement.

To return to the graphite, it would be expected

FIG. 2.

that the amount, size, and distribution of this constituent would have a tremendous effect on the tenacity, and a study of graphite from the point of view of these properties opens up further interesting possibilities. The three micros herewith show various forms of graphite. Fig. 2, I consider, shows the presence of amorphous carbon.

The factors influencing the character of the graphite and the manner in which this influence is brought about are too numerous to mention at this time. However, from the point of view of tensile strength, it will be interesting to point out one or two of these factors. In the first place, it is now generally accepted that the temperature at which the carbon is absorbed has a large influence on the amount and also character of the free carbon in the final iron. To illustrate how this influence is probably brought about, imagine a charge of cast-iron heated up to, say, 1,400 deg. C. in the cupola in contact with coke; then, providing it is in contact with the coke for a sufficient length of time, it will absorb about 6 per cent. of carbon. As this iron cools down, the excess of carbon over 4.3 per cent. will be thrown out of solution, and throughout the whole mass of iron there will be a sort of a flow of particles of free

carbon to the surface. Now, should the rate of cooling be quick, some of this free carbon or kish will be entangled in the gradually thickening liquid. These entangled particles then exert what is known as a "nucleus action" on the remainder of the carbide, thus precipitating further free carbon. This is an extremely important action, and Figs. 3 and 4 give an illustration of its effects. The samples were taken from two gas-engine liners of exactly the same weight

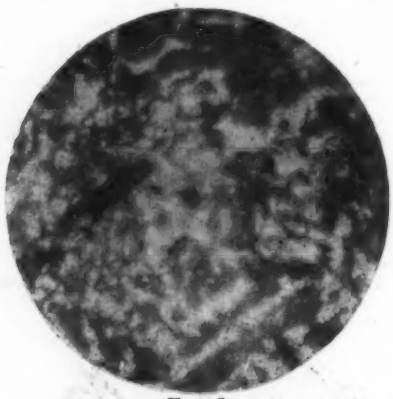

FIG. 3.

and size from exactly the same position, the two liners being cast out of the same ladle. The cast iron had been kept in the cupola for some time before casting, and thus it can be assumed that the metal to some extent was supersaturated.

Again, anyone who has any experience of chemical analysis will probably have experienced the difficulty of igniting the graphitic residues of various cast iron.

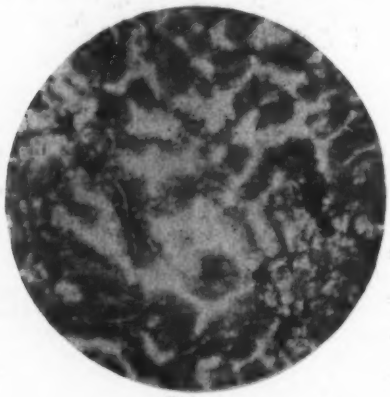

FIG. 4.

This is especially true of samples of kish, which all points to difference in character, and therefore difference in influence of the graphite on the final iron.

The foregoing notes are only introductory to a subject which I hope to discuss further at some future date

Discussion.

MR. H. SHERBURN remarked that the subject was a very difficult one for the ordinary lay mind to follow, though he quite agreed it had been a most interesting Paper. The question of carbon in iron was coming more to the front, and was receiving increasing attention from foundrymen, but microscopical work was necessarily confined to a few individuals.

MR. W. H. SHERBURN said Mr. Hurst stated that graphite was an enemy to the ironfounder. A man usually looked upon anything he did not understand in that light, but the time often came when he regarded it as a friend, especially if he knew what to do with it.

The CHAIRMAN thought it would have been more interesting if Mr. Hurst had explained if the carbon got into the metal at any given point.

MR. HURST replied that with regard to graphite being an enemy, it was quite true that it might become a friend. In reply to the Chairman, he might say that it was a fact carbon was added to cast iron while melting. It was as well to use the highest possible blast pressure in order to get satisfactory results. By quicker melting the graphite was got in finer form, but he could not explain why; indeed, the question was still under discussion.

THE MANUFACTURE OF FERRO-MANGANESE.—According to Bulletin 77 issued by the United States Bureau of Mines, dealing with the history and manufacture of ferro-manganese, the industrial importance of ferro began in 1886 with the introduction of the Bessemer process, which required a strong deoxidising agent to produce a sound steel. In 1866, Prieger, of Bonn, Germany, made in the crucible some ferro containing 70 to 80 per cent. manganese. At Terre-Noire, France, a little later it was made in the open-hearth furnace and crucible in a combination process. The first ferro-manganese to be made in the blast furnace was produced in Sweden in 1873, and contained 33 per cent. manganese. In 1875, at Terre-Noire, Pourcel made in the blast furnace some ferro that contained 75 to 80 per cent. manganese. The results of a modern typical blast-furnace run, including figures as to the ore used, and the slag and the alloy produced, are given in the table below. In this run the average amount of coke consumed was 2.37 tons per ton of ferro produced. Of the total manganese charged 76.9 per cent. was saved and 23.1 per cent. lost.

Ore		Slag		Ferromanganese	
Constituent.	Per cent.	Constituent.	Per cent.	Constituent.	Per cent.
Mn ..	51.6	SiO_2 ..	30.32	Mn ..	80.20
Fe ..	1.45	FeO ..	1.41	Fe ..	11.80
P ..	0.173	MnO ..	8.52	Si ..	1.16
SiO_2 ..	7.80	Al_2O_3 ..	10.88	P ..	0.38
Al_2O_3 ..	1.12	CaO ..	41.34	C ..	6.46
CaO ..	1.80	MgO ..	2.96		
MgO ..	2.18	P_2O_5 ..	0.01		
BaO ..	2.20	CaS ..	3.94		
		BaO ..	0.48		

The loss of manganese by volatilisation, or as dust, varies between 15 and 20 per cent. of the total quantity of manganese charged. The average total loss is about 30 per cent., of which 10 per cent. goes to the slag and 20 per cent. is volatilised or lost as dust. Any phosphorus in the ore goes to the metal, but there is no difficulty in slagging the sulphur. No more than 0.02 per cent. of phosphorus should be present for each 10 per cent. of manganese in the ore. When ferro-manganese is being made in the electric furnace, the electrodes and voltage are regulated so as to prevent arcing. With a mixture of 813 parts of ore containing 30 per cent. manganese, 178 parts of anthracite coal (4 to 5 per cent. ash), and 90 parts fluorspar, about 450 lbs. of product was obtained per ton of mixture treated. The product contained 85 per cent. manganese. Of the total manganese charged 26.8 per cent. was lost by volatilisation, as dust, and in the slag. Ferro-manganese made in the electric furnace has considerably lower carbon content than the blast-furnace ferro, and is used in the molten state by the ferro-alloy manufacturer for making silico-manganese.

Precision in Cupola Operation.*

By David Townshend.

Unfortunately, no concerted action has as yet been taken by the various manufacturers of cupolas to standardise the variables which form the basis for a properly constructed apparatus. The number, position and size of the tuyeres, location and size of windbox, diameter of windpipe as affected by distance between cupola and blower, shape of interior outline of the lining, and other points might be scientifically determined and forever removed from the field of speculation or of personal opinion.

The importance of securing and maintaining a proper combination of carbon and oxygen is shown by the fact that carbon, when burned completely to CO_2, gives off about 14,500 B.T.U., while carbon burned to CO produces only 4,450 B.T.U., a direct loss of about 10,000 B.T.U. by imperfect combustion. As both CO and CO_2 are colourless, odourless gases, the loss may be taking place and be continuous without the knowledge of the operator; in fact, nothing but an analysis of the gases will definitely fix the responsibility. By the use of automatic CO_2 recorders the gases may be studied and then controlled until a uniform method of operation has been evolved.

Every pound of pure carbon theoretically requires 2.67 lb. of oxygen or 11.52 lb. of air for its complete combustion to CO_2. Air contains only about 23 per cent. of oxygen. If we assume, for the sake of illustration only, that the cupola is running on a 10 to 1 melting ratio, for each 2,000 lbs. of iron we will use 200 lbs. of coke of which, say, 175.5 lbs. will be carbon requiring 2,022 lbs. of air for its complete combustion. Air is usually measured in cubic feet, but as the weight varies with the temperature, moisture, etc., we may assume that it will be supplied at an average temperature of 70 deg. F. in which case the above coke will require 154.7 cub. ft. of free air per pound of carbon or a total of 27,150 cub. ft. which is not far from the 30,000 cub. ft. of free air usually considered necessary to melt one ton of iron.

The proper distribution of the air entering the cupola and its union with the fuel will cure many ills such as burnt, cold and spongy iron, which are the result not so much of the quality of the metal charged, as of errors in melting and manipulation.

Considerable care is generally taken to measure and record the amount of iron and coke which are put into the cupola. But whoever weighs or measures the air that is being used? That this is just as important an item as any other cannot be disputed when it is remembered that of the above 27,150 cub. ft. of air, about 77 per cent. is nitrogen, which must be heated to the temperature of the furnace and then discharged into the atmosphere without having done any work. unless it is utilised to pre-heat the incoming air, as is done in the blast furnace.

A continuous supply of air at a constant pressure can only be obtained by having an air-tight chamber of sufficient size between the cupola and the source of air supply to equalise all pulsations, belt slippages, etc., which will otherwise affect conditions for proper working. The present wind-box supplied by the cupola builder does not give a sufficient volume to properly equalise the pressure. It is not only important to get the right amount of air for complete combustion into the cupola, but equally so not to get too much, as a surplus has a decided cooling effect. The amount of air necessary for the complete combustion of the fuel put into a cupola depends upon a considerable number of variables, chief of which are the carbon content of the fuel, pressure and distribution of the air, and constancy of supply of both fuel and air.

It is a difficult operation to determine the volume of air going into the cupola at any given time. This is usually done by means of a Pitot tube, which consists of two copper tubes of small diameter (¼ in.) and having their ends bent over at right angles and tapered, the two tubes being fastened together so that the bent ends point in opposite directions. The free ends of the tube are attached to the draft or pressure gauges in such a manner that the readings will represent the pressure in one tube and the suction in the other, the difference being the measure of the velocity of the air in the blast pipe and from which the volume of air passing may be determined. The position of the two bent tubes in the blast pipe gives different readings and an average must be obtained to get any scientific results. As the velocity of air under pressure passing through a pipe varies considerably from the centre to the periphery, the results obtained must be averaged in order to get any reliable information as to the volume, which of course is the product of the area of the pipe in square feet multiplied by the velocity in feet per unit of time as calculated from the Pitot tube readings. Because of the pressures produced in the two Pitot tubes being very small, it is at present necessary to use two inclined manometers reading in inches of water and use the differences for making the velocity calculations.

The ideal volume meter would be one which would be entirely within the blast pipe itself, and through which all the air passing from the blower or fan to cupola must go, there being no average to compute and no loss due to leakage or friction.

For the best results, there should be provided a relief valve which can be set to maintain any pressure desired and which will automatically open if an excessive pressure is generated. The usual practice with cupola tenders when they want to slack down is to reduce the speed of the blower or, in some instances, shut it down altogether. This, of course, applies more particularly to positive-pressure blowers, as fans will take care of themselves if the blast pipe is closed off. Blowers, however, should never be stopped after being started, but should be relieved and the melting rate regulated by means of a relief valve on the blast pipe line and near to the cupola.

In order to know whether we have obtained the best results possible by control of the pressure and amount of the blast and its proper distribution in the cupola, we must also know if it has completely performed its intended function during the melting operation. This can best be ascertained by an analysis of the waste gases in the stack above the charging door, taken in conjunction with pyrometric temperature readings at several points in the cupola.

In order to secure a proper gas sample from the stack, the sampling tube should go all the way across the inside of the lining and be furnished with a number of equidistant holes to assure a proper average. Care should also be taken to shut off temporarily any air which may be induced through the charging door.

* From a Paper read before the Philadelphia Foundrymen's Association.

Annealing for the Production of Malleable-Iron Castings.

The feature of annealing which is common to both classes of malleable cast iron is that of breaking down the carbide by prolonged heating. Since, however, the processes differ materially in the matter of decarburisation and consequently in annealing temperatures and packing material, it is necessary to treat them separately.

Ore Annealing.

In European or Reaumur practice, as previously stated, the material which performs part of the function of annealing must essentially be of an oxidising nature, and the most suitable (in fact, the only practicable) material is ferric oxide in the form of red hematite ore. This is packed round the castings, which are placed in annealing pans or pots of grey cast iron of suitable thickness and design, varying according to the size and nature of the castings to be treated. The ore also serves the purpose of supporting the castings and preventing to some extent the distortion which would inevitably take place were they heated without packing. It also affords a very necessary protection from direct contact with the flame of the furnace, which would result in burnt and useless castings.

Annealing Ore.—The character of the ore is a very important matter, for if it is too active (too high in oxygen) it tends to cause pitting of the surface of the castings, thus spoiling them for use. If, on the other hand, it is too low in oxygen it does not act as an effective decarburiser and annealing is too slow or imperfect. A mistake is often made by malleable-iron founders in regarding any ore as suitable for annealing if it is a red hematite ore. Some ores which would be quite suitable for blast-furnace use are quite unsuitable for annealing, on account of both nature and chemical composition. Yet the vague rule is generally accepted that a red hematite ore of a granular nature (a convenient size being that which will pass through a ¾-in. riddle) will serve as a packing, with the addition of about 10 per cent. of new ore each time it is re-used. To appreciate the requisite properties in an annealing ore it is necessary to remember that it must stand the annealing temperature without fusing and must also act as an oxidiser to the carbon in the metal. As already stated, a good new ore should not be used undiluted by used ore, or the castings will be badly pitted by the action of the oxygen. But if an ore is used which is not sufficiently strong in oxygen to deal with the carbon, the castings will not be annealed. It is different with the low-sulphur iron used in the black-heart process, for in that work a quite neutral packing will give good results with a suitable iron, for the simple reason that oxidation is not an essential of the annealing. But it is the first essential in European of Reaumur practice, and if the ore is not sufficiently active a higher temperature will be required, with a consequent danger of fusing the ore and spoiling the castings.

Red hematite ore is composed chiefly of ferric oxide (F_2O_3) ferrous oxide (FeO), silica, and traces of other substances, amongst which are lime, sulphur (in the form of sulphide of iron), magnesia, alumina, and magnetic oxide of iron (Fe_3O_4). The effective constituent in the annealing process is the ferric oxide, which gives up part of its oxygen to the carbon, with the production of ferrous oxide. Therefore, an excess of ferrous oxide in a presumably new ore would probably indicate adulteration with spent ore. A good new ore should not contain more than 1.5 per cent. of ferrous oxide.

A reasonable specification for the ore would set the following limits:—

		Per cent.
Ferric oxide (Fe_2O_3)	not under	80.0
Ferrous oxide (FeO)	not over	1.5
Silica	,,	12.0*
Lime	,,	1.5
Sulphur	,,	0.1
Moisture	,,	3.0

* If higher, lime should be present only in traces.

The ore, as purchased, should be dry, of a brick-red colour, and the pieces sufficiently hard to resist crushing between the finger and thumb. As previously stated, a low percentage of ferric oxide renders the ore weak without the additions of spent ore which are customary. The following typical analyses of ores (taken on the dried ore) which gave uniformly satisfactory results, are quoted by F. H. Hurren.†:—

Good Annealing Ores.

	1.	2.	3.	4.	5.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Ferrous-oxide	1.23	1.21	1.14	1.44	0.12
Ferric-oxide	88.80	81.40	83.28	82.21	95.36
Silica	7.80	11.14	13.72	11.53	3.50
Lime	Nil.	Nil.	1.45	0.35	Nil.
Sulphur	0.09	0.02	0.03	Trace.	Nil.

No. 5 is particularly good, and is stated to be the best out of 150 samples.

The same writer quotes the following as analyses of unsatisfactory ores:—

Unsatisfactory Annealing Ores.

	6.	7.	8.	9.	10.	11.	12.	13.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Ferrous-oxide	2.52	0.12	0.06	0.64	0.20	1.01	0.67	1.04
Ferric oxide	53.60	59.05	75.73	76.72	78.57	74.02	76.60	77.30
Silica	26.60	25.02	15.58	17.20	18.75	17.70	14.21	13.40
Lime	6.24	12.16	3.57	1.25	1.60	1.28	2.72	4.21
Sulphur	0.57	0.54	0.02	Trace.	0.04	0.06	Trace.	0.02

Castings annealed in ores Nos. 6 and 7, were covered with a dark-brown, semi-opaque glass, presumably resulting from a combination of the excessive lime with the silica to form a fusible calcium-silicate, which analysis revealed to be the composition of the substance. It was almost impossible to remove this hard, brittle coating from the castings. Nos 8 and 9 required prolonged heating to produce the desired results in the castings.

† FOUNDRY TRADE JOURNAL. November, 1910.

The following are analyses of some ores:—

Red Hematite Ore.

(HARRISON, AINSLIE & COMPANY, LIMITED, LINDAL IRON MINES, ULVERSTONE.)

	Soft selected lumpy ore.	
	Natural. Per cent.	Dried. Per cent.
Ferric oxide	86.87	88.00
Ferrous oxide	Trace.	Trace.
Silica	8.51	8.63
Alumina	2.17	2.20
Lime	0.98	1.00
Magnesia	0.073	0.074
Phosphorus	0.010	0.011
Sulphur	Trace.	Trace.
Arsenic	0.084	0.085
Oxide of manganese	Trace.	Trace.
Iron	60.81	61.60

Barrow Hematite Iron Ore.

	"Kidney" ore.	"Pencil" ore.	"Best" ore.	Washed ore. (Fine.)	Washed ore. (Coarse)
Ferric oxide	97.86	97.43	85.86	76.56	86.50
Moisture	0.50	0.50	4.60	7.60	3.74
Phosphoric acid	0.52	0.02	0.01	0.04	0.01
Sulphuric acid	Trace.	Trace.	Trace.	Trace.	Trace.
Insoluble residue	1.04	1.60	4.96	11.91	6.45
Soluble residue	0.58	0.45	4.57	3.89	3.30
Phosphorus	0.008	0.008	0.006	0.016	0.007
Sulphur	Trace.	Trace.	Trace.	Trace.	Trace.

Method of Packing.—The white-iron castings, being extremely brittle, require careful handling and packing. After being cleaned of adherent moulding

FIG. 1.—PACKING ANNEALING PANS WITH HARD CASTINGS IN ORE.

sand, they are sorted approximately into various sizes and placed in the annealing pans, starting first with a bed of ore a couple of inches thick. The castings should not be allowed to touch each other, and all interstices should be well packed with ore, following with further castings when the first are covered, and so on until the pan is full. A further pan or ring is then placed on, and the joint luted with fireclay and sand, and the packing process continued. When the desired height (governed by the construction of the oven) is attained, a lid is placed on and the joint luted as before. The tier of pans is then picked up by a suitable trolley and placed in the oven, the annealer arranging them according to classes, so that the thick castings get sufficient heat for their proper annealing, while the thin ones do not get over-heated.

When the oven is full of pans it is closed and sealed, the method depending on the construction

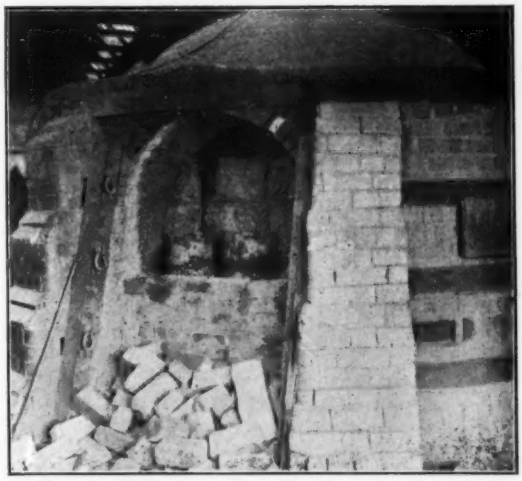

FIG. 2.—BEEHIVE ANNEALING OVEN AT DAIMLER WORKS, READY FOR BRICKING-UP AND HEATING.

of the oven (which will be dealt with later), and the firing is commenced and continued for the necessary period. It was the practice at one time to vary the temperature, attaining the maximum heat for a time and then allowing a decrease of temperature for a period, followed by an increase of temperature to the maximum, and so on. But that practice is not adopted in modern foundries, as it only prolongs the process unnecessarily.

The oven temperature should be gauged by a suitable pyrometer and regulated accordingly, though some foundries appear to be satisfied with gauging the temperature by sight and the period of annealing by the scaling effect on the pans. Such practice, however, is too empirical to be recommended, though it undoubtedly has served in the past with experienced men.

When it is judged that the maximum temperature has been maintained long enough, the oven is allowed to cool down slowly, this cooling taking from 12 hours onward, according to the construction of the oven and the thickness of work being annealed. The slow cooling after heating is essential, or the carbon in the castings will not come out of combination, but will remain as combined carbon, giving hard castings. It must be remembered that the annealing temperature is above the critical point, and hence the separation process takes place on the downward grade of the temperature. It is common to allow the castings to remain in the annealing pans until they are cool enough to be handled, this ensuring a slow cooling.

The rate of heating up is important, particularly with heavy sections. If the maximum temperature

is attained too rapidly the castings are liable to crack through irregular expansion strains, so the first period of annealing in such cases is one of slow increment, about 1,200 deg. F. (650 deg. C.), being maintained for a considerable time, the maximum of about 1,800 deg. F. (about 980 deg. C.) being finally attained and maintained for the necessary period ranging from 3 to 14 days. The fires are then allowed to burn out, and the sealed oven "soaks"

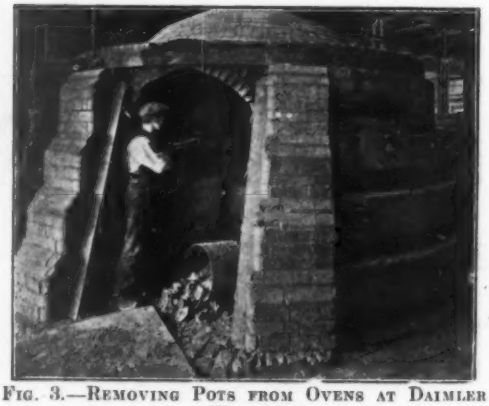

FIG. 3.—REMOVING POTS FROM OVENS AT DAIMLER WORKS.

or gradually cools off, at the conclusion of which process the heat-treatment is finished.

It may here be interesting to mention the practice followed at the Daimler Company's foundry. At the Daimler Works the castings are packed in iron pans (Fig. 1) with a pure hematite ore, mixed as usual with a portion of spent black ore, and the pans are stacked in concentric rings in the large beehive-shaped ovens shown in Figs. 2 and 3, which are gas-fired, each from a separate producer. The gas and air inlets are arranged round the circumference of the oven, also the main exits to the stack. The oven temperature is thus under control, and regular firing can be ensured. A temperature of about 960 deg. C. is maintained for the requisite period—in this case about six days.

The reduction of carbon is considerable, as will be seen from the following analyses of a casting before and after annealing:—

	Before.	After.
	Per cent.	Per cent.
Carbon, total	2.90	1.87
" combined	2.90	0.57
" graphitic	Trace.	1.30
Silicon	0.50	0.50

The total carbon after annealing can only be considered as approximate as this varies in different sections, and from the exterior inwards of the same section.

Annealing for Black-heart Castings.

In general, the process just discussed holds good for black-heart or American malleable cast iron, with the difference that a different packing material is used and the maximum temperature is maintained for a much shorter period. The temperature ranges, according to the class of work, from 750 degrees C. to 900 degrees C., and the heating process takes about 40 to 50 hours as a minimum, apart from the slow cooling. With cupola iron the temperature requires to be somewhat higher than with air-furnace metal, supposed to be due to the higher sulphur, but possibly as a result of carbon and silicon being out of ratio for rapid annealing.

Packing Materials.—While rolling-mill scale is generally considered as the packing material for black-heart castings, it is by no means essential, and is only influential as affecting the rim of the casting, in so far as it acts as an oxidising or decarburising medium. On this account black-heart work annealed in rolling-mill scale has a characteristic white or decarburised rim (ferrite) surrounding a body of metal in which the carbon has been separated as temper carbon but not removed. Other packing materials serve quite well, and amongst those that have been used may be mentioned sand, lime, cement, manganese di-oxide, fire-clay, fine graphite, carborundum, and aluminia. While the packing material affects the rim it does not influence the interior structure.

According to recent experiments by Leasman and Storey at the University of Wisconsin, U.S.A., with materials which are stable at the annealing temperature the structure is uniformly a layer of ferrite; with oxidising materials a deep layer of ferrite is formed; and with carbon, charcoal, graphite and case-carbonising materials, a skin structure is formed which varies from a low-carbon to a high-carbon steel. These investigators further state that the physical structure of the packing materials also affects the metal's skin structure. Materials which are loose and porous and allow a free circulation of the air produce a ferrite exterior to the casting. Without the oxygen of the air the structure of the exterior portion does not differ from the interior. In

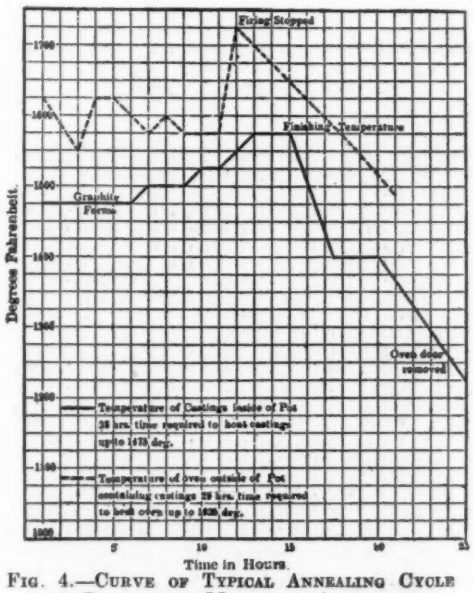
Firing Stopped
Finishing Temperature
Graphite Forms
Oven door removed
Degrees Fahrenheit.
Time in Hours.
Temperature of Castings inside of Pot
38 hrs. time required to heat castings up to 1475 deg.
Temperature of oven outside of Pot containing castings 38 hrs. time required to heat oven up to 1625 deg.

FIG. 4.—CURVE OF TYPICAL ANNEALING CYCLE FOR BLACKHEART MALLEABLE ANNEALING.

one experiment which showed this, brass turnings were used as a packing material; the brass fused at the annealing temperature and completely enclosed the specimen, preventing the oxygen from coming into contact with it. Although a normal malleable structure was formed in the other specimens annealed in the same heat, the temper carbon in this specimen extended to the brass coating which had formed on the specimen. In this connection it is suggested as probable that the atmosphere of the furnace and the looseness of the packing rather than the chemical

action of the scale determines the rim structure when rolling-mill scale is used. It should be mentioned, however, that the atmosphere of the experimental furnace used was highly oxidising as compared with that of the commercial furnace.

As evidence of the small effect of the packing material on the structure, it may be mentioned that in at least one American plant where scale is regularly used, when a rush comes anything within reach is used as a packing material, usually ashes and cinders, and no difference in structure is apparent between the two malleable products. In another plant brick-dust is replacing scale with no apparent change in structure. Storey claims that large castings can be annealed by merely heating in a muffle, care being taken to prevent excessive oxidation. The structure is the same in all cases, consisting of an exterior layer of ferrite, or pearlite, or both, and an interior of temper carbon and ferrite.

Temperature of Annealing.—The best temperature for annealing is governed somewhat by the composition of the metal, but it is very desirable not to exceed the proper heat; for though a higher temperature may reduce the time requisite, the product is poorer in strength. Nor will prolonged heating at a low temperature give good results, unless the temperature in question is above the critical point at which the carbide decomposes. This point appears to lie between 740 and 830 deg. for low-sulphur irons. The above-mentioned authorities (Storey and Leasman) experimented with an iron of the following composition, in bars ¾ by ¾ by 10 in.:—

	Per cent.
Total (combined) carbon	2.60 to 2.70
Silicon	0.65 to 0.70
Sulphur	0.055 to 0.060
Phosphorus	0.140
Manganese	0.27

The low-carbon resulted from steel addition to the melt. The conclusions arrived at were that with this iron annealing for 50 hours at 860 degrees secured a complete breakdown of the cementite; annealing at 740 to 760 degrees for 50 hours resulted in a partial breakdown, though by continuing the heat to double the time it is probable that a complete breakdown could have been secured. No decomposition could be observed in specimens annealed below 670 degrees.

The effect of the rate of cooling was also considered, and it was found that when the rate was slow (the drop from 900 degrees to 670 degrees requiring 38 hours) the interior of the specimen showed an excellent malleable structure of ferrite and temper carbon; when the same drop in temperature required but 22 hours, the resulting interior structure showed ferrite, temper carbon and areas of pearlite; when the time occupied but 15 hours, the interior showed pearlite, temper carbon, and a small amount of ferrite.

It appears that a fast rate of cooling after annealing results in a steely structure, and that the critical cooling range is between 740 degrees and 830 degrees. Therefore, if the rate of cooling is sufficiently slow in the critical range, all of the carbon in the undecomposed austenite will be precipitated in that range. If the carbon is entirely precipitated in the critical range the rate of cooling below 700 degrees has little effect upon the iron—a fact that would discount the value of leaving the castings in the packing to get quite cool, if the cooling through the higher ranges of temperature has been sufficiently slow. Practice, in any case, has indicated that the decomposition of the carbide is not complete at the annealing temperature, but continues during cooling through the critical range; while practice also confirms the suggestion that rapid cooling after passing the critical range has no influence on the carbon, for it is common to cool rapidly from about 650 deg. C.

When investigating annealing temperatures in black-heart practice, Mr. W. Putnam* submitted bars of the same metal to 11 malleable-iron foundries to be annealed in accordance with their usual practice. The analysis was as follows:—Silicon, 0.74 per cent.; sulphur, 0.041 per cent.; phosphorus, 0.148 per cent.; manganese, 0.24 per cent.; combined carbon, 2.70 per cent. The results obtained on the annealed bars indicated considerable irregularities in results obtained in different foundries. The critical and proper annealing temperature was ascertained on a number of hard-iron specimens ranging from 2.35 to 3 per cent. total carbon. These temperatures ranged from 1,525 deg. F. for 2.35 per cent. carbon to 1,650 deg. F. for 3 per cent. carbon. The curves in the diagram, Fig. 4, were given as representing a typical annealing cycle in an oven containing 14 tons of castings, the carbon content being 2.65 per cent. Putnam states that after reaching the annealing temperature there is no further rise in the temperature of the metal until all of the carbon has changed into the graphitic condition, and that as soon as the change has been completed the temperature will rise in accordance with the temperature of the oven. Referring to the diagram in question, it is certainly shown that at 1,475 deg. C. (800 deg. C.) the rise in oven temperature is not reflected in the castings until what Putnam claims to be the formation of the graphite is complete. The arrest in the cooling of the castings, despite regular cooling of the oven, however, suggests to the present writer that it is at the critical point in the range between 740 and 830 deg. C. (in this particular case 760 deg.) that the actual formation of annealing carbon takes place. This would imply that the higher arrest on the heating-up curve indicates a change in the condition of the carbide preparatory to the separation of temper carbon.

ELECTRO-PERCUSSIVE WELDING.—In a Paper on this subject by Messrs. C. E. Skinner and L. W. Chubb, of the Westinghouse Company, presented before the American Electro-Chemical Society recently, the authors stated that in the process of electro-percussive welding two wires are welded together by causing a condenser discharge to pass between the ends of the wires in the moment when they are pressed together by mechanical force. The generation of the heat is so localised, so sudden and so intense that there is no time for unequal heat conduction through the shanks of the wire, and the ends are melted and even vaporised whether the melting point is high or low. For this reason metals of different kinds can be welded together independent of their electrical resistance, melting point, or heat conductance. Any combination of metals which has ever been tried will weld together, but the joints will not be permanent with such combinations as aluminium and tin, or lead and iron. Many of the alloys of most metals are very hard and brittle. As an example, there are alloys near both ends of the copper-aluminium series which are unworkable; yet electro-percussive welds between these two metals are said to be so ductile that they may be worked in a die, forged, or rolled into thin foil. Any alloy formed at the weld must range from 100 per cent. copper on one side to 100 per cent. aluminium on the other; but possibly the brittle combinations are so thin that the joint as a whole is flexible and ductile.

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* Detroit Foundrymen's Association.

Foundry Equipment Details.

By J. M. L.

The writer has frequently noticed the lack of eye for details exhibited in some foundries, for it must be understood by every experienced foundryman that a good shop, cupolas, ladles, cranes, etc., does not constitute a fully-equipped shop. One must not

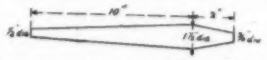


FIG. 1.—STANDARD GATE PIN.

overlook the minor details. Of course, boxes are among the first items, and as a good number of these can be made to commence with in open sand, that matter is easily got over, but when these have been made and work proper is started, and something is

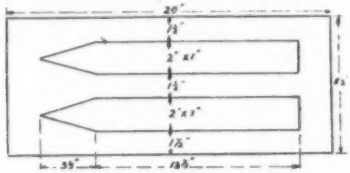


FIG. 2.—WOOD PLATE FOR STANDARD STAKES.

expected in the way of production, then one begins to look for wedges, clamps, stakes, etc., which are probably not available, with the result a few wood wedges are used and stakes, etc., made temporarily. But alas! one forgets and becomes so accustomed to the wood that one never dreams of having the proper article made. Having been up against this trouble,

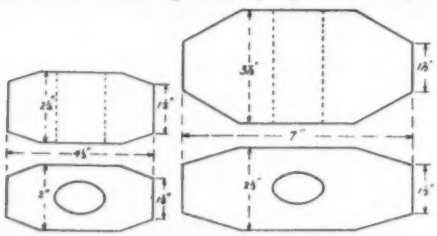


FIG. 3.—CAST-IRON HAMMER HEADS.

which caused a great loss of time, the writer took good care to remedy matters on the second occasion, and had patterns, and in some cases wood plates,

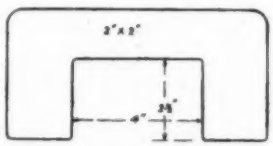


FIG. 4.—CLAMP FOR LUGS OF BOXES.

made for the different articles, which after the second cast gave a goodly supply of requisites. It might be mentioned that most of these patterns and plates are still working, and we always have an abundance of the articles mentioned. The appended sketches, tables, etc., may be useful to any readers similarly placed. Everything works out marvellously cheap, as all can be made by a very young apprentice.

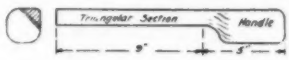


FIG. 5.—FILLETING STICK FOR MOULDING BOXES.

The gate pin shown in Fig. 1 may be made in either cast-iron -or hard-wood. Fig. 2 shows a wood plate for casting standard stakes. Fig. 3 shows two sizes of cast-iron hammers heads for knocking out boxes

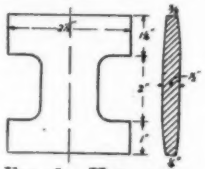
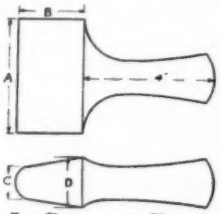


FIG. 6.—HARD-WOOD DIBBLE FOR LIGHT CORE-IRONS, ETC.

after casting, the first head being for an ordinary hand-hammer shaft and the larger one for a 2 ft. 6 in. shaft. A clamp to suit lugs of most

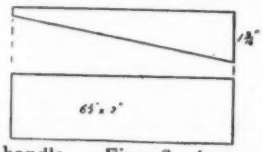


A. Ins.	B. Ins.	C. Ins.	D. Ins.
3	1¼	⅝	¼
3	1½	¾	1¼
3½	1½	1¼	1½
3½	2	1½	1½

Two off each size.

FIG. 7.—RANGE OF HARD-WOOD DIBBLES FOR HEAVY CORE-IRONS, ETC.

boxes is shown in Fig. 4. The hard-wood filleting stick for moulding boxes shown in Fig. 5, is held in the corner while ramming, and is then simply drawn



out by the handle. Fig. 6 shows a hard-wood dibble for light core-irons, etc. Fig. 7 shows the design and sizes for a range of hardwood dibbles

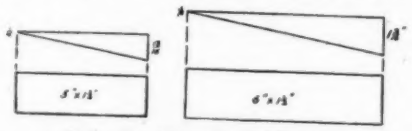


FIG. 8.—CAST IRON WEDGES.

suitable for heavy core-irons, gratings, etc. Fig. 8 shows a range of cast-iron wedges suitable for most purposes. These should be plated so that a big lot may be made at one cast.

Composition of Cast Iron.

At a meeting of the Halifax Branch of the British Foundrymen's Association, on April 17, Mr. Carrick in the chair, Mr. J. G. Robinson (Halifax) addressed the members on "The Composition of Cast Iron." Cast iron, he said, differed from other kinds of iron in containing a large amount of impurities. Many people, when speaking about cast iron, stated the percentage of the silicon or manganese necessary for certain classes of work, but omitted to mention the percentage of carbon, although it was the latter element which had the greatest influence on the resulting castings. The amount usually present varied from 2 per cent. to 4.5 per cent., and usually two distinct forms were recognised, which were known respectively as "graphite" or free carbon and combined carbon. The amount of the graphite and the size of the flakes attained was determined by the composition of the metal and the rate of cooling. Graphitic carbon reduced shrinkage by reason of its expansion at the time it separated. For strong castings 0.5 per cent. combined carbon was required. Professor Howe had suggested that the maximum strength was obtained when the combined carbon was between 1.0 and 1.2 per cent., and the graphite as low as possible. This, however, would be too hard to be readily machined. However, it was combined carbon which determined the strength, closed the grain and increased the shrinkage and chill. All cast iron contained more or less silicon, the proportion ranging from 0.25 per cent. to 4.5 per cent. In itself, silicon had a hardening effect, but by reason of its effect on the carbon was really used as a softener, as it tended to promote the separation of carbon as graphite.

Manganese was usually present in pig-iron in amounts varying from traces up to 2 or 3 per cent. Few foundry irons, however, were offered which contained more than 2 per cent. The effect of manganese was to combine with the carbon and dissolve in the iron, thus retarding and preventing the separation of graphite and rendering the metal harder, whiter, closer, denser, and stronger. Phosphorus was present in about the same proportion as manganese, and although it had little direct influence on the state of the carbon, it lowered the percentage of total carbon present. Mr. Geo. Hailstone stated that with 2 per cent. of phosphorus in cast iron there was not more than 2 per cent. carbon. The beneficial effects up to a point were, the lowering of the melting point, the greater fluidity of the metal and the reduction of external shrinkage. Above 1.25 per cent. P. was not safe in large castings. It made the metal whiter and more brittle, and consequently weaker. Dr. Stead suggested 0.7 per cent., but he (the author) had obtained 18 tons tensile with 1.2 per cent. Sulphur was too often made responsible by the foundryman for all the faults of the metal and defects of castings, and many founders were hard to convince that it had any redeeming feature. The general effects were, that the iron was made harder and more rigid, and perhaps brittle; was liable to cast more unsoundly, especially in green-sand moulds; was more sluggish, contracted more, and was thus liable to produce drawn and distorted castings with initial stress of unknown value. It increased the percentage of combined carbon by preventing its separation as graphite and neutralised the useful effect of silicon.

The changes that took place when iron was melted in the cupola, continued the speaker, depended upon the construction of the cupola, the pressure and volume of blast, composition of the coke used and the grade of iron being melted. In melting ordinary grey iron, unless the total carbon was abnormally high, there was practically no change in the percentage, but if the total carbon was very low, it would tend to increase to its normal content by taking carbon from the coke. The loss of silicon ranged from 0.2 to 0.3 per cent., according to the percentage originally in the mixture; an average could be taken as 0.25 per cent. Manganese loss was 0.1 per cent.; phosphorus remained practically constant; sulphur gained 0.038 per cent. The resultant castings were necessarily of a harder and closer nature than the original charge. The composition of iron to be used for making a casting depended upon the size of that casting, *i.e.*, its thickness as affecting the rate of cooling. The mixture of iron used to make large castings, close, solid and strong, would make a small thin casting hard, flinty and impossible to machine. If only light castings were to be produced, mixtures that were low in sulphur, fairly high in phosphorus, and high in silicon should be used. These elements gave softness, and at the same time sufficient strength for ordinary purposes. If large and heavy work was to be made, where soundness and strength were essential, the iron should be harder and be produced by using irons fairly low in silicon, lower in phosphorus, and with more sulphur than could be allowed in light castings.

Mr. Pemberton said the foundryman could not get satisfaction for high-class castings by working only to the analysis. If he wanted a constant test of 15 tons tensile and two tons transverse on a 2 in. by 1 in. bar, with $\frac{4}{5}$ in. deflection, it was almost impossible with a high total carbon say from 3.5 per cent. to 3.7 per cent. Some people spoke of tensile tests, some of transverse tests, and some of deflection, but it was not right to separate them; they should all be considered. If a micrograph of cast iron showed a network structure it would give good tests all round, and if an iron had more than 3.2 per cent. of total carbon then tensile tests fell. Silicon should not be more than 1.2 per cent. for good tensile results.

With regard to the conditions of smelting in the blast furnace, continued Mr. Pemberton, an iron with 3 or 3.2 per cent. carbon made in a blast furnace at a high temperature showed large flakes of graphite; if melted at a low temperature small flakes of graphite; and as a cupola did not melt graphite the large flakes remained as such. He did not think there was a great deal to fear from sulphur if the iron was cast hot, but if it was cast sluggish, then they could look out for sulphur blobs.

Mr. Carrick asked Mr. Pemberton for an analysis for a high-class mixture. Mr. Pemberton gave the following:—Graphite carbon, 2.3 per cent.; combined carbon, 0.8 per cent.; silicon, not more than 1.2 per cent.; manganese, not more than 0.8 per cent.; phosphorus, not more than 0.75 per cent.; sulphur, not more than 0.08 per cent. (cold blast).

Mr. Berry said that a lot of specifications never demanded a tensile test. He was often asked for a transverse test of 1¼ tons on a 2 in. by 1 in. bar, 0.3 deflection, and was getting it regularly with steel scrap; in fact he often got as high as two tons transverse.

Mr. Pemberton said that two tons transverse could be got without steel; the analysis given would give it, but they must know their iron.

Mr. Carrick reminded Mr. Pemberton that there were different classes of high-class iron. The one which had been given was a high-class cylinder iron, but Mr. Berry would be expected to supply a high-class iron for machine tools, and as they could not all have laboratories, and could not get the blast-furnacemen to give the chemical analysis, they had to find ways and means themselves. He (Mr. Carrick) said he used a contraction test by means of micrometers, and he found it a very handy and accurate way of working. As an example, on a ¾ in. bar 12 in. long, he could easily arrive at the amount of silicon by the contraction shown. The mixture given by Mr. Pemberton would work out at 0.175; 0.153 contraction would show 28 to 30 cwts. transverse test, and 0.156 contraction 32 cwts. He had been supplied with iron on one occasion which was supposed to contain 2.5 per cent. of silicon, and instead of showing 0.147 contraction it showed 0.160; therefore it contained 1.9 per cent. silicon. He sent a sample away for analysis, and his conclusion was verified.

Mr. Robinson said that Mr. Carrick's remarks on the contraction tests for silicon proved what he said about carbon, that the physical properties of cast iron depended upon the total amount of carbon and the state of that carbon. He said he had seen castings made with a machining allowance on the pattern actually shorter than they ought to have been when machined. As to sulphur, he did not fear it despite the fact so many foundrymen blamed it for nearly everything that happened; but the iron must be cast hot. He thought Mr. Pemberton had made a mistake when he said that manganese up to a certain percentage had a hardening effect. Manganese was a hardener all the way.

The Action of Heat and Furnace Gases on Sand-Lime Bricks.

In a recent number of the "Revue de Métallurgie," M. E. Damour gives an account of some tests on sand-lime bricks. According to the makers of these bricks they are resistant to heat. As, however, they have been shown to consist either of a hydrated silicate of lime or of calcium hydroxide (which decompose at 200 deg. C. and 550 deg. C. respectively) it is the opinion of chemists that heat will destroy the cementing material and, as a result, cause disintegration. For the purpose of deciding the question, the author subjected commercial sand-lime bricks to two series of tests; one conducted in an oxidising atmosphere (under the influence of heat only), and the other in a hot furnace flue, in which the bricks were also exposed to carbon dioxide.

In the first series, the bricks were heated for two hours at constant temperatures, rising by 50 deg. C. at a time, from 100 deg. to 800 deg. C., and finally at 1,000 deg. C. The loss in weight and the resistance to crushing were then measured. The determination of the loss in weight was for the purpose of ascertaining the lowest temperature of complete dehydration. Incidentally, it revealed the occurrence of a rapid process of carbonation in which the water of hydration is replaced by carbonic acid, according to the equation $Ca(OH)_2 + CO_2 = CaCO_3 + H_2O$ which increases as the temperature rises above 200 deg. C. This reaction was particularly noticeable in the case of crushed samples of the brick, which present a far greater surface of material to the action of CO_2 than do whole bricks. The direct estimation of the carbon dioxide present in the powdered brick calcined at moderate temperatures showed an increase from 1.3 to 3.93 per cent. For the whole bricks, the loss in weight increased progressively with the heating temperature employed, from 3 per cent. at 200 deg. to 6.01 per cent. at 800 deg. C.

Above 550 deg. C., however, it remained fairly constant, indicating that this is the temperature of complete dehydration of the hydroxides or hydrosilicates constituting the binding material. At the same time, this temperature is the one at which the bricks begin to exhibit a considerable decrease in crushing strength. For instance, the crushing strength after heating for two hours at 150 deg. was 413 kg. per sq. cm., whereas at 550 deg. it had fallen to 226 kg., and at 600 deg. to 177 kg., after which it decreased fairly regularly to 81 kg., at 1,000 deg. C.

The loss of strength is at first slow, and even at 500 deg. C. amounts to only one-third, so that the bricks may be said to stand fairly well up to that temperature. They even retain a certain amount of cohesion up to 800 deg. Beyond this, however, the dissociation temperature of calcium carbonate is reached and the mass literally falls to pieces. On being heated to about 1,500 deg., the silica combines with the lime to form a fusible silicate capable of acting as a bind; but this operation would be very costly, and does not seem to afford the possibility of the product competing successfully with the ordinary silica bricks used in metallurgy.

In investigating the effect of fumes, the bricks were heated in a reverberatory furnace for four, six, eight, 30 and 60 hours. In this series some difficulty was encountered in interpreting the results, owing to the considerable difference in the two parcels of bricks tested, though both were of the same make and appearance. The initial strength of the one parcel of bricks was less than half that of the other. Ultimately the cause was traced to a difference in the density of the bricks, in consequence of the difference in the amount of compression given in the course of manufacture. When, however, they were compared with other bricks of similar density the anomalies disappeared. The values obtained indicate that heating at 300-400 deg. C. causes a loss in weight, which attains a maximum between the second and the sixth hour of heating, after which the weight increases again at first very quickly in presence of furnace gases, in consequence of the substitution of CO_2 for water of hydration. On exposure to the air for several days after the heating at 300-400 deg. C., the bricks regain a portion of their lost weight, bringing the permanent loss down to, generally, less than 1 per cent. This is attributed to the fact that part of the lime in the brick is combined with silica as a silicate which on heating is dehydrated, but not decomposed, whilst the rest is free and thus able to absorb carbon dioxide from the gases. If the whole of the lime could be converted into carbonate the bricks would show a permanent gain in weight and not a loss.

On exposure to furnace gases the crushing strength of the brick is decreased in proportion as the heating is prolonged, proving the injurious effect of these gases on the cohesion of the material. The average crushing strength after a few hours exposure was only about one-third of that of the brick in the original condition.

From this the author concludes that lime-sand bricks ought not to be used in the construction of any furnace parts, flues or chimneys where they will be exposed to the action of carbon dioxide. In cases where such bricks can be used it is advisable to see that they are of uniform density, since otherwise their wearing properties are liable to be very irregular.

Researches on the Iron, Silicon, and Carbon Alloys.*

By Georges Charpy (Paris) and Andre Cornu-Thenard (Ville).

The properties of the iron-carbon-silicon alloys, and, in particular, the transformations they undergo under the influence of variations in temperature, present peculiarities which do not appear to have been fully elucidated by the investigations hitherto carried out, and amongst which may be mentioned those of Sir Robert Hadfield, Guillet, Baker, and others. The authors have therefore reinvestigated these transformations by taking into consideration successive series of metals containing varying amounts of silicon and carbon, and endeavouring both to co-ordinate and to confirm the results of thermal, chemical, and microscopic analysis.

On the other hand, this investigation appears to them to have shed some light on the iron-carbon system itself; by taking into consideration, so to speak, the continuity of the perturbations introduced by the progressive variation of an element it is possible to arrive, by extrapolation, at an understanding of what would occur in the complete absence of that element.

The work has been carried out on two main groups of alloys:—

(1) Steels, which have been divided into dead soft steels containing 0.10 to 0.15 per cent. of carbon (the silicon varying from 0.1 to 7 per cent.), and semi-hard steels containing 0.35 to 0.40 per cent. of carbon (the silicon varying from 0.1 to 4.5 per cent.).

(2) Cast iron with 2 per cent. of carbon (silicon varying from 0.1 to 7 per cent.).

The authors briefly sum up as follows the conclusions to which their research have led, and connect them with the results already established:—

Influence of Silicon on the A1, A2, *and* A3 *Points.*—The authors are able to confirm, as different observers have pointed out, that the A3 point rapidly decreases when the percentage of silicon rises, at the same time rising very slightly on the temperature scale.

The temperature at which the A1 perturbation takes place rises with the silicon percentage, this point reaching and then passing the A2 point while becoming gradually fainter. After reaching a given percentage of the metalloid and for a given rate of variation of temperature, the A1 point completely disappears, and all the carbon of the metal is then found in the state of graphite. It is even possible to cause a predetermined disappearance of this point by treating the sample, before applying the thermal test, in such a manner as to produce the complete transformation of the carbon.

The A2 point falls gradually in the temperature scale when the percentage of silicon rises, losing little by little its intensity the while, but still persisting in a very clear manner in metals containing up to 7 per cent. of the metalloid. At this juncture the A2 point is the only anomaly which appears on thermal investigation, in iron alloys containing low carbon, even when the rate of the variation in temperature be sufficiently accelerated. The individuality of the A2 point is the more clearly brought into light by the fact that it is possible, at will, to retain in or to eliminate from its vicinity the A1 point by bringing into play the precipitation of the graphite.

Although the A2 point is not manifested on dilatation, it is not impossible that it corresponds with an allotropic transformation. It is not necessary, from the authors' point of view, that for the definition of such a transformation it should manifest itself by its influence over the whole of the physical properties of the substance under consideration. It should suffice for it to influence any one of those properties.

Influence of Silicon on the Solubility of Carbon in Iron.—The present research is overshadowed by the following fact, which has already been pointed out by various observers, but which the authors believe themselves to have established in a more accurate manner than has hitherto been done: every increase in the proportion of silicon present in the metal diminishes the solubility of carbon in iron.

The presence of the metalloid reacts, naturally, on the one hand, on the temperature limits within which the precipitation of graphite takes place, and, on the other hand, on the rate of the transformation of the cementite. The authors have thus been able to show that with alloys containing very little carbon and about 3 per cent. of silicon, there exists a temperature zone within which, by making the rate of cooling intervene, the complete decomposition of the carbon may be brought about.

Finally, the influence of silicon on the rate of reaction is such that in certain irons the graphite precipitation gives rise to a thermal point. This anomaly, which may coexist with the A1 point, possesses special sharpness when the latter has disappeared. It is then found that it rises rapidly on the temperature scale, when the percentage of silicon rises.

Graphic Representation of the Phenomena.—The authors point out, at the beginning of this Paper, that the researches on carburised ferro-silicon alloys appeared to them capable of affording information on those cases beyond its range where silicon was absent. It is well known that complete agreement has not been reached amongst metallurgists on the subject of the iron-carbon diagram. While most metallurgists favour the double diagram (graphite system and cementite system) described by Le Chatelier, Heyn, Charpy, Benedicks, etc., some observers appear to tend to revert to the single diagram, drawn up in the first instance by Roozeboom. Without entering into a detailed comparison, the authors confine themselves to stating that all the facts they have observed and recorded in the present Paper conform very naturally with the scheme of the double diagram, and thus appear to constitute a further argument in its support.

* Abstract of Paper presented before the Iron and Steel Institute, May, 1915.

The Diffusion of Carbon in Iron.*

By F. W. Adams, B.Sc. (Wiggin Scholar in Metallurgy, University of Birmingham).

Sir F. Abel, in 1881, first indicated the existence of a carbide of iron of the formula Fe_3C, and most metallurgists now accept this formula as representing the composition of the most important compound of iron and carbon. The conditions of stability of this carbide, however, are still subjects of controversy.

During the interval that has elapsed since Abel's original discovery many investigations have been conducted with the object of determining the conditions of formation, and the properties of other car-

* Abstract of Paper presented before the Iron and Steel Institute, May 1915.

bides of iron. The results of Wittorf's researches indicate the probable occurrence of three additional carbides, having the respective formulas, FeC_2, Fe_4C, and FeC. As proofs of the existence of these carbides are not yet complete, and their range of stability does not extend below 1,200 deg. C., a consideration of their influence on the diffusion of carbon in iron is not included within the scope of the present Paper.

In a Paper which was presented to this Institute in 1897 by Mr. G. P. Royston, an experiment was described which was conducted as follows:—A piece of steel containing 0.95 per cent. of carbon was placed in a porcelain tube, and heated *in vacuo* at 900 deg. C. for twelve hours. The sample weighed practically the same after as before heating. Two pieces of mild steel, containing 0.15 per cent. of carbon, were then placed in the tube along with the previous high-carbon sample, but not in contact with it. These three pieces were then heated for twelve hours *in vacuo* at 900 deg. C. This treatment produced practically no alteration in their weight. The high-carbon specimen was then placed in contact with the two low-carbon pieces, and the three samples subjected to the same treatment as in the previous cases. The specimens were then cooled *in vacuo*, and reweighed. The results showed that the low-carbon pieces had increased in weight, whilst the high-carbon piece had lost an amount equivalent to that gained by the low-carbon pieces. On determining their respective carbon contents after this treatment, it was found that the percentage loss of carbon in the high-carbon piece was exactly balanced by the percentage gain of carbon in the low-carbon pieces. From the results of this experiment it would seem that the carbon only had diffused from the inner high-carbon piece to the outer low-carbon pieces. Mr. Royston suggested that the carbon was apparently in solution as such, in the iron, at the temperature of the experiment, viz., 900 deg. C., and should in that case obey the ordinary laws of diffusion, and diffuse through the iron until the pressure of solution was equalised throughout.

The author's research was undertaken with the view of confirming Mr. Royston's experiment, and, if possible, to obtain further evidence to prove whether, at temperatures between 900 deg. to 1,000 deg. C., carbon diffuses as such or as iron carbide.

So much controversy has turned on the cementation of iron *in vacuo*, even by solid carbon, at temperatures below the melting point of the iron, that at present it would be unsatisfactory to draw conclusions other than those indicated by the experiments. These conclusions are summarised as follows:—

(1) Iron and steel, when heated *in vacuo* between 900 deg. to 1,000 deg. C., lose weight.

(2) Samples of steel, white iron, and, to a lesser extent, grey cast iron, will weld together, when heated *in vacuo* within the temperature range of 900 deg. to 1,000 deg. C., provided their surfaces are clean, and in perfect metallic contact. The amount of this welding or intercrystallisation thus taking place between two samples of iron or steel is not dependent on the quantity of carbon present in them, or on the difference of carbon content of the two specimens, but only on the perfection of contact between their respective surfaces.

(3) When welding occurs between two specimens of iron of unequal carbon content, the transference of carbon, by consequent diffusion from the high-carbon steel to the steel of lower carbon content, is much more rapid than the transference of carbon effected by the agency of a gaseous vehicle such as carbon monoxide.

(4) There can be no tendency to equalisation of carbon by diffusion, between two samples of steel of varying carbon content, when they are heated together *in vacuo* between 900 deg. to 1,000 deg. C. unless their respective surfaces are in perfect metallic contact, in which case welding results, and thus prevents any further investigation on the lines indicated by the results of Mr. Royston's experiment.

ELECTRIC FURNACES FOR STEEL CASTINGS.—In a Paper to be presented at a meeting of the American Institute of Mining Engineers at San Francisco, Cal., in September, Mr. W. G. Kranz, discussing the electric furnace in the foundry, states that the National Malleable Castings Company installed a 6-ton Héroult furnace in 1912. This furnace has three electrodes 17 in. in diameter, uses three-phase 60-cycle current, and is equipped with Thury regulators. The power factor of the furnace is 94 per cent. Since July, 1912, the furnace has been in continuous operation, producing up to the present time over 20,000 tons of both carbon and alloy steels of varying analyses and of exceptional quality. Both cold- and hot-metal charges have been used, with a power consumption of about 150 kw.-hr. per ton in the case of hot-metal charges and from 500 to 600 kw.-hr. per ton in the case of cold charges. Too much cannot be said about the refining possibilities of the electric furnace, for no other method of steel manufacture can compete with the electric in this respect. In proper operation lies the whole secret of success. That steel has been made electrically means nothing, for when the furnace is operated under oxidising conditions the quality is no better than that of open-hearth material; but when properly made, electric steel is as good as that made in the crucible, and very much less expensive. The most important of the many advantages of electric steel castings over those made by the ordinary processes are briefly summarised, and it should be kept in mind that these apply not only to carbon steels but to the alloy steels as well:—(1) Absence of segregation, elimination of oxides, and absolute uniformity of composition regardless of atmospheric conditions which affect open-hearth furnaces; (2) almost entire elimination of sulphur is possible (an important consideration in steel castings) and complete control of the other elements; (3) great tenacity, giving ability to withstand much more abuse and fatigue without rupture; (4) high ratio of elastic limit to ultimate strength; (5) a more ready response to heat treatment and with much more uniform results; (6) perfect control of pouring temperature, combined with ability to obtain very hot metal, so that light and intricate shapes are readily cast. There is no doubt, says the author, as to the practical elimination of sulphur in electric-furnace operation. We have repeatedly reduced the sulphur to a trace in irons containing as high as 0.30 per cent. sulphur. During the past year we have developed an electric steel having remarkable physical qualities after heat treatment. This was accomplished without resorting to any of the high-priced alloys. The steel, when subjected to shock or static pull, will stand from four to five times as much stress without distortion as the ordinary open-hearth product. This assertion is not based on a few tests, but on over 3,000.

WAR DEMAND FOR MACHINE-TOOLS.—Heavy purchases of machine-tools for use in the manufacture of munitions of war continue. So thoroughly has the market in the United States been ransacked that to succeed in picking up a single second-hand lathe now is considered a stroke of fortune. The inability to secure lathes for early delivery has led to the placing of a large amount of business for future delivery, and as a result American lathe manufacturers in many cases have disposed of the greater part of their output over the remainder of the year.

The Foundry Cupola.

At a recent meeting of the Lancashire Branch of the British Foundrymen's Association, held at Bolton, Mr. T. W. Markland in the chair, Mr. Robert Buchanan, F.R.S.A., of Birmingham, delivered a lecture on "The Genesis of the Foundry Cupola," which in substance has previously appeared in our columns. After discussing the antiquity of iron and the furnaces producing it, he dealt with the bloomery furnace, the old English blast furnace, the coking of coal, the cupola furnace, the old type of cupola, the Thwaites' cupola, the Whiting cupola, the Machiell cupola, contours of linings, materials for linings, single or double rows of tuyeres, and the blast and its effects.

In the discussion which followed, Mr. Harrison said that in speaking of the effects of little or much coke being used, Mr. Buchanan did not mention the quantities of coke or the effects of the blast. Did not the increase of blast counteract the effects of the increase of coke? The use of two or three rows of tuyeres in a cupola was a debateable point. His own experience with two cupolas of identical size, one having two and the other three rows of tuyeres—the latter having a little more blast area than the former—was that while 4 or 5 tons per hour was got from the one, up to 7 tons was got from the other? They had tried it, not once, but many times, and on each occasion the extra melting power was got from the cupola with three rows of tuyeres. The height of the bed was the same in each case.

Mr. Walker asked whether, when one tuyere was 6 or 8 in. higher than the other, that would make any difference? Then, in speaking of the quantity of coke and the pressure of air, the lecturer had not mentioned the quantity of coke. Would he give them that?

Mr. Simkiss said his own practice was not to allow the coke to burn through before charging. He himself was using a melting furnace with 8 tuyeres in two rows, 6 in. by 4 in. of the expanding type, and they worked very well. A remark of Mr. Buchanan's might lead any one who had not had much experience, to infer that softness or hardness depended upon blast, but that was not the case. Hardness and softness depended on the mixtures. They should not put soft metals in the cupola and attempt to harden them by blast, or *vice versa*. With regard to charging methods, in charging with a bucket a mass of cold metal was thrown down the cupola, and the result would be much inferior to the spreading of the iron in layers, which could be done by men at the cupola mouth.

Mr. Buchanan, referring to some remarks on the use of steel in cupola mixtures, said he had not heard before of 70 per cent. of steel so used; the highest he knew of was about 45 per cent. Replying to Mr. Harrison, he said he should consider the best proportion of tuyere area to cupola was about one to nine, but they might possibly do very good work with one to six. He could not, however, attempt to lay down any law, as it was only by experiment, working upon similar conditions, that they could find out a rule for themselves. He had been asked if he ever came across mottled places? He had seen hard spots, but it was a very debateable question where they came from. Sometimes it seemed as if the metal had been splashed, and not taken up again; why it should be so he did not know, unless the silicon had been oxidised; but he did not know that that was the whole explanation. He did not think sulphur had to do with the formation of hard pellets in the grey iron. Mr. Harrison's experience in getting 4 or 5 tons with two rows of tuyeres and 7 tons with three rows was interesting, and rather unusual. He had tried the experiment, and found it was not worth the coke—in fact, he could get his results better with two than with three rows. He was not able to tell any one what was an ideal tuyere, unless he knew all the conditions. It was pretty certain that the proper area of tuyeres could only be found by experiment, but if a number of pipes were used, one ought to be slightly above the other. He quite agreed with Mr. Simkiss about the coke just being kindled, and he also agreed with him that they had not yet got the right design of cupola, which would come some day. He was not prepared to say more than that the ideal cupola was one that would go on melting week after week. Mr. Simkiss also remarked that charging by bucket was not as good as charging by hand. In a small cupola that might be true, but in others he did not see any harm in charging with the bucket. He (Mr. Buchanan) did not approve of keeping the slag hole open all the time. A slight hole was a very useful adjunct, but the air should not be blowing through all the time.

A cordial vote of thanks was accorded to Mr. Buchanan for his address.

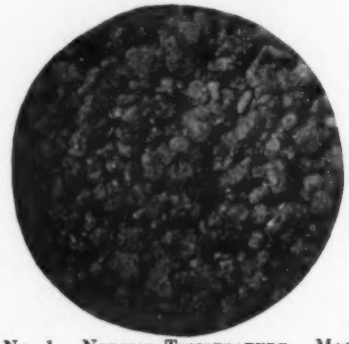
AUTOMATIC TURNING MACHINE ECONOMIES.—In their "Monthly Review," Messrs. Alfred Herbert, Limited, point out that much work is regularly done on engine lathes which ought to be done on turret lathes, and much work is done on turret lathes which ought to be done on automatic turning machines, and the relative costs of production on the three classes of machines are given regarding a toggle carrier for the friction clutches of a lathe headstock. The work used to be done on an engine lathe at a piecework price of 2s. 3d. each, but was transferred to a turret lathe which enabled the price to be reduced to 1s. 6d. each, the saving being 33⅓ per cent. This seemed to be a good saving, but it was found later that the work could be done on an automatic turning machine at 4¼d., amounting to a saving of 75 per cent. over the turret lathe and 83½ per cent. over the engine lathe.

METALLURGICAL RESEARCH AND WARFARE.—In the course of a recent address before a graduates' meeting of the Institution of Mechanical Engineers, Sir Robert A. Hadfield made reference to his own research work, and said that low-hysteresis steel had been found exceedingly valuable for electrical purposes, chiefly for transformers. The first transformer made of the low-hysteresis material was constructed in 1903 for the Sheffield City Corporation Electric Light and Supply Department. It was a small beginning, but it had been estimated that in 1909 the use of the low-hysteresis material was effecting a saving in America of something like 10 million dollars annually. This figure had since been greatly exceeded, probably doubled. In great Britain, Germany, and other countries the savings effected had been proportionately as large. In connection with research on the effect of carbon on iron and steel alloys, highly interesting details were given of the battle between the "armour which could not be fractured" and the "projectile which no armour could resist." The function of the cap on the armour-piercing shell was described; this, and the flight of the shell, its impact with and perforation of an armour-plate, and subsequent bursting, being illustrated by remarkable cinematograph films. The lecturer directed attention to a 13.5-inch shell which had been so little damaged after perforating a 12-inch plate that it could have been ground, put into the gun, and fired again. A 15-inch shell which went through a 15-inch plate was in equally good condition.

Tests of Foundry Sands for Refractory Values.

By Algernon Lewin Curtis, M.E.

Material Tested :—**LANCASHIRE SAND** (Ormskirk). *Weight of Sample* :—100 Grammes. *Colour and Description* :—Darkish Red. *Consistency* :—Medium Coarse, Weak. *Surface Factor or Size* :—(Grammes per cent.)—Retained on 50 sieve, 15.730 ; Retained on 100 sieve, 57.140 ; Sieved through 100 sieve, 27.130. *Water Required for Maximum Cohesiveness when Dried One Hour at 100 Deg. Cent.*:—Three C.C. per cent. *Venting Capacity of 1 Cu. In. when Mixed 400 Times with 3 per cent. Water and Rammed at a Pressure of 20 lbs. per Square Inch* :—About 7.0 lbs. Air Pressure. *Plate* :—Wellington and Ward "Anti-Screen." *Objective.*—1" Watson.



No. 1.—Normal Temperature. Mag. × 50 Diams.

Remarks.—Material Weak and Dirty. Works Badly in Moulds, and Very Gritty.

No. 2.—Exposure to 1,200° C. Mag. × 50 Diams.

Remarks.—Test Piece Expanded $\frac{1}{32}$ in. in the Form of a Camber in a Length of 2½ in. Specimen Weak. Bleaching Out of Clay Substance Begun.

No. 3.—Exposure to 1,300° C. Mag. × 50 Diams.

Remarks.—Test Piece Expanded as in Fig. 2. Specimen Very Weak. Slight Exfoliation. The Finer Grains Fusing in Small Masses.

No. 4.—Exposure to 1,400° C. Mag. × 50 Diams.

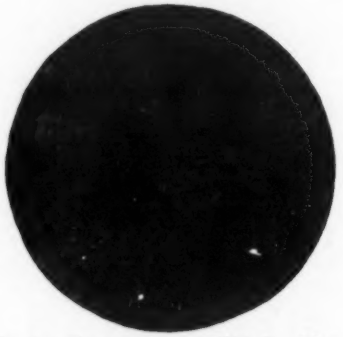
Remarks.—Test Piece Broken by Heat. Specimen Very Weak. Material Partly Fused in Dense Aggregates, showing Heavy Fissuring.

No. 5.—Exposure to 1,500° C. Mag. × 50 Diams.

Remarks.—Test Piece Broken by Heat. Considerable Exfoliation. Material nearly Completely Fused, showing Deep Fissuring.

No. 6.—Exposure to 1,600° C. Mag. × 50 Diams.

Remarks.—Test Piece Broken by Heat. More Exfoliation. Material Completely Fused, showing very Heavy Pitting and Fissuring.



No. 7.—Exposure to 1,700° C. Mag. × 50 Diams.

Remarks.—Test Piece Broken by Heat. Very Weak. Greater Exfoliation. Material Completely Fused to a Greyish-white Glass Tinged with Spots of Iron, showing very Heavy Fissuring.

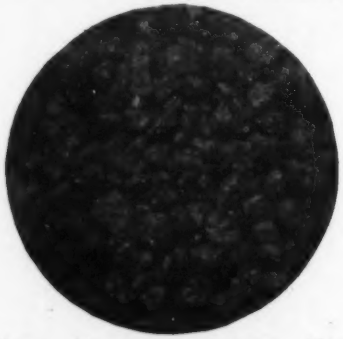
No. 8.—Exposure to 1,800° C. Mag. × 50 Diams.

Remarks.—Test Piece Broken by Heat. Very Weak. Very great Exfoliation. Material Deeply Fused to a Greyish-white Glass Tinged with Spots of Iron.

TINGED WITH SPOTS OF IRON, SHOWING VERY HEAVY FISSURING.

WITH SPOTS OF IRON.

Material Tested :—**NOTTINGHAMSHIRE SAND (Worksop Medium).** *Weight of Sample* :—100 Grammes. *Colour and Description* :—Light Brick Red.] *Consistency* :—Very Weak, Medium Size. *Surface Factor or Size* :—(Grammes per cent.)—Retained on 50 sieve, 2.865 ; Retained on 100 sieve, 80.600 ; Sieved through a 100 sieve, 16.535. *Water Required for Maximum Cohesiveness when Dried One Hour at* 100 *Deg. Cent.* :—Three C.C. per cent. *Venting Capacity of* 1 *Cu. In. when Mixed* 400 *Times with* 3 *per cent. Water and Rammed at a Pressure of* 20 *lbs. per Square Inch* :—About 3 lbs. Air Pressure. *Plate*—Wellington and Ward "Anti-Screen." *Objective* 1" Watson.



No. 1.—NORMAL TEMPERATURE. MAG. × 50 DIAMS.

REMARKS.—MATERIAL VERY WEAK AND GRITTY. WORKS BADLY IN MOULDS.

No. 2.—EXPOSURE TO 1,200° C. MAG. × 50 DIAMS.

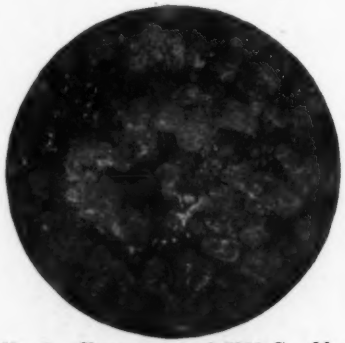
REMARKS.—TEST PIECE BROKEN BY HEAT. BLEACHING OUT OF THE LITTLE CLAY SUBSTANCE CONTAINED.

No. 3.—EXPOSURE TO 1,300° C. MAG × 50 DIAMS.

REMARKS.—TEST PIECE BROKEN BY HEAT. SPECIMEN VERY WEAK. MATERIAL LITTLE AFFECTED BY HEAT.

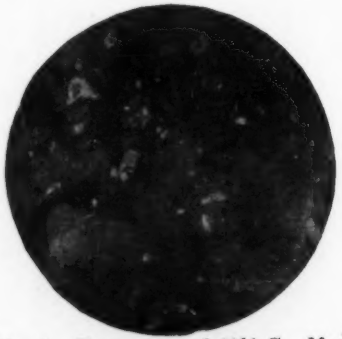
No. 4.—EXPOSURE TO 1,400° C. MAG. × 50 DIAMS.

REMARKS.—TEST PIECE BROKEN BY HEAT. SPECIMEN VERY WEAK, SHOWING SLIGHT EXFOLIATION. MATERIAL PARTLY FUSED IN DENSE AGGREGATES, SHOWING DEEP FISSURING AND PITTING.



No. 5.—EXPOSURE TO 1,500° C. MAG. × 50 DIAMS.

REMARKS.—TEST PIECE BROKEN BY HEAT. MATERIAL NEARLY COMPLETELY FUSED IN MORE DENSE AGGREGATES, SHOWING VERY HEAVY FISSURING AND PITTING.



No. 6.—EXPOSURE TO 1,600° C. MAG. × 50 DIAMS.

REMARKS.—TEST PIECE BROKEN BY HEAT. CONSIDERABLE EXFOLIATION. SPECIMEN VERY WEAK. MATERIAL COMPLETELY FUSED TO A WHITISH GLASS, SHOWING HEAVY FISSURING DUE TO IRON

No. 7.—EXPOSURE TO 1,700° C. MAG. × 50 DIAMS.

REMARKS.—TEST PIECE BROKEN BY HEAT. GREAT EXFOLIATION. SPECIMEN MUCH WEAKER. MATERIAL MUCH MORE FUSED TO A WHITISH GLASS, SHOWING HEAVY FISSURING, DUE TO IRON.

No. 8.—EXPOSURE TO 1,800° C. MAG. × 50 DIAMS.

REMARKS.—TEST PIECE BROKEN BY HEAT. MUCH GREATER EXFOLIATION. WHOLE SURFACE OF SPECIMEN DEEPLY FUSED TO A WHITISH GLASS, DEEPLY PITTED AND FISSURED.

Analyses of Tin and Antimony.

The London Metal Exchange published, in 1912, analyses of many of the different commercial brands of tin. With the purpose of trying to obtain concordant results and eventually agreeing on suitable methods of analysis, Mr. W. A. Cowan, in the United States, has undertaken a series of analyses in co-operation with Mr. D. M. Buck, of the American Sheet and Tin Plate Company, Mr. A. M. Smoot, of Messrs. Ledoux & Company, and Mr. A. H. Knight, of Liverpool, through the kindness of Mr. R. F. Pearce, of Messrs. Williams, Harvey & Company, Limited. Particulars of these analyses are given in a Paper read at the recent Chicago meeting of the American Institute of Metals. Mr. Cowan is, however, careful to point out that, owing to the wide geographical distribution of the sources of supply of the various brands, it was found impracticable to obtain fair samples representative of each, and therefore, for this investigation simply an individual pig was taken at random from a commercial lot at hand of each of the following brands:—Banka, marked M E; Straits, marked J & C; Australian, Pyrmont Smelting Company, Sydney, marked B; English common, Williams, Harvey & Company, branded with a lamb and flag and Mellanear. In one case, through Mr. R. F. Pearce, a fair representative sample of a brand was obtained, namely, English refined, Williams, Harvey & Company, class A, Standard Contract of London Metal Exchange.

According to the rules of the London Metal Exchange pig tin is good delivery under their form of contract only when accompanied by an analysis, certifying that the metal contains a percentage of pure tin of either 99 or 99.75 per cent., according to whether the quality is that of common tin or of refined tin. It is the practice of the English manufacturers to brand pigs of common tin with a lamb and flag. The results of analysis of these samples should be identified with only an individual pig of tin. They do not necessarily represent an average composition of all lots of the various brands, except in the case of the English refined tin.

Mr. A. H. Knight reports that this latter sample was received directly by him from the registered warehouse in the form of fifteen sealed packets of sawings representative of 750 tons; that they were melted together by dropping them into an iron ladle containing boiling palm oil; there was apparently no oxidation and consequently no dross formed, and only a slight loss of weight; the melted tin was well mixed with a piece of hardwood and cast into small ingots. This sample was received too late to be included by all the participants in the work, and up to the present has been analysed only by Mr. A. H. Knight and Mr. Cowan. The other samples of tin were prepared by remelting the whole original pig in a clean small kettle to a temperature of about 280 deg. C. (=536 deg. F.). This was thoroughly stirred and mixed, and thin bars poured into a cold mould, so that they would set quickly with as little segregation as possible. The bars were cut in two and several pieces sent to each analyst, no two halves of the same bar being included in any one set of samples.

The samples were prepared for analysis by sawing the bars clear through in a number of places evenly distributed throughout their length, with a carefully cleaned hack saw blade, then passing a magnet through the sawings to remove any particles of steel; or by rolling out the bars into a very thin ribbon of

Banka.

	A	B	C	D
	%	%	%	%
Lead	trace	0.010	trace	trace
Arsenic	0.024	0.004	trace	none
Antimony	0.038	none	0.006	0.006
Copper	0.003	0.009	0.002	0.004
Cadmium	....	none	....	none
Bismuth	....	0.002	Nil	none
Iron	trace	0.004	0.023	0.019
Zinc	trace	....	....	trace
Ni & Co	....	none	Nil	none
Manganese	....	none	....	none
Tungsten	....	....	....	none
Sulphur	trace	....	trace	trace
Phosphorus	trace	none	Nil	0.008
Tin	99.935*	99.971*	99.963	99.963*
Total	100.000%	100.000%	99.994%	100.000%

* By difference.

Straits.

	A	B	C	D
Lead	0.057	0.080	0.049	0.064
Arsenic	0.084	0.072	0.058	0.077
Antimony	0.103	none	0.018	0.018
Copper	0.013	0.027	0.020	0.020
Cadmium	....	none	....	none
Bismuth	....	0.003	0.004	none
Iron	trace	0.005	0.003	0.005
Zinc	trace	....	....	0.015
Ni & Co	....	none	Nil	none
Manganese	....	none	....	none
Tungsten	....	....	....	none
Sulphur	trace	....	trace	0.009
Phosphorus	trace	none	Nil	0.010
Tin	99.743*	99.813*	99.831	99.782*
Total	100.000%	100.000%	99.983%	100.000%

* By difference.

Pyrmont (Australian)

	A	B	C	D
Lead	0.019	0.045	0.016	0.045
Arsenic	0.020	0.035	0.019	0.038
Antimony	0.054	0.074	0.051	0.098
Copper	0.023	0.027	0.015	0.024
Cadmium	....	none	....	none
Bismuth	....	0.010	0.007	none
Iron	trace	0.003	0.003	0.003
Zinc	trace	....	....	0.010
Ni & Co	....	none	Nil	none
Manganese	....	none	....	none
Tungsten	....	....	....	none
Sulphur	trace	....	trace	trace
Phosphorus	trace	none	Nil	0.020
Tin	99.784*	99.806*	99.866	99.762*
Total	100.000%	100.000%	99.977%	100.000%

* By difference.

Williams, Harvey & Company (English)

	Common.				Refined.	
	A	B	C	D	C	D
Lead	0.339	0.374	0.380	0.387	trace	0.010
Arsenic	0.038	0.078	0.060	0.077	0.049	0.061
Antimony	0.336	0.220	0.215	0.252	0.032	0.039
Copper	0.075	0.100	0.060	0.090	0.015	0.014
Cadmium	....	none	....	none	....	none
Bismuth	....	0.070	0.059	0.064	0.002	none
Iron	trace	0.008	0.004	0.002	trace	0.003
Zinc	trace	....	....	0.006	....	0.012
Ni & Co	..	none	0.007	none	Nil	none
Manganese	....	none	....	none	....	none
Tungsten	....	....	....	none	....	none
Sulphur	trace	....	0.002	0.006	trace	trace
Phosphorus	trace	none	trace	0.007	Nil	trace
Tin	99.212*	99.150*	99.260	99.109*	99.920	99.861*
Total	100.000	100.000	100.047	100.000	100.018	100.000

* By difference

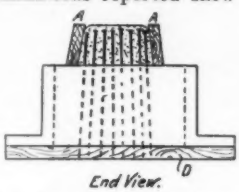
foil, after removing any surface contamination, and cutting sections to represent a fair sample of the whole length of the ribbon; or by filing complete cross-sections at the ends and in the middle of each half bar with a coarse rasp, then treating the filings with a magnet.

On comparing the results first obtained, it was found that some of the determinations showed too wide a variance, and the need of further investigation was demonstrated. In some cases the figures first obtained have been revised, but Mr. Cowan states that the analyses have not yet reached a close agreement on all results, nor have uniform methods of analysis been agreed upon.

In the comparison of pig-tin analyses the letters denote the names of the analysts as follows:—A = American Sheet and Tin Plate Company; B = Ledoux & Company; C A. H. Knight; D = National Lead Company.

Antimony.

A similar investigation was made as regards antimony. The samples of antimony were obtained in a similar way, by taking individual ingots from lots bought in the market of the following brands:—Cookson's, branded "C"; Hallett's, branded "H"; Japanese, branded "M C"; Chinese, branded with two overlapping circles "OO," and marked Wahchang, Mining and Smelting Company, Changsha, Hunan, China. The determinations reported show here also the need of much more work being done. We give the results so far obtained:—



End View.

Metallic Antimony Analyses.

	Cookson's "C" A	Cookson's "C" D	Hallett's "H" A	Hallett's "H" D
Lead	0.041	0.102	0.669	0.718
Tin	0.035	trace	0.175	0.012
Arsenic	trace	0.092	trace	0.210
Bismuth	....	none	....	none
Copper	0.040	0.046	0.038	0.046
Cadmium	....	none	....	none
Iron	0.010	0.004	0.014	0.007
Zinc	trace	0.034	trace	0.023
Ni & Co	....	0.028	...	none
Sulphur	..	0.086	..	0.128
Antimony*	....	99.608	....	98.856
Total		100.000%		100.000%

* By difference.

	Japanese "MC" A	Japanese "MC" D	Chinese "OO" A	Chinese "OO" D
Lead	0.443	0.424	0.018	0.029
Tin	0.175	0.012	0.035	none
Arsenic	0.008	0.095	0.017	0.090
Bismuth	....	none	....	none
Copper	0.034	0.043	0.008	0.012
Cadmium	....	none	....	none
Iron	0.015	0.007	0.007	0.004
Zinc	trace	0.023	trace	0.027
Ni & Co	....	none	....	trace
Sulphur	....	0.201	....	0.078
Antimony*	....	99.195	....	99.760
Total		100.000%		100.000%

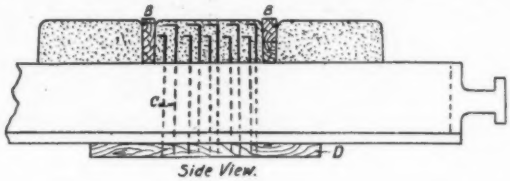
Analyses marked A are by the American Sheet and Tin Plate Company, and D by the National Lead Company.

A Foundry Emergency.

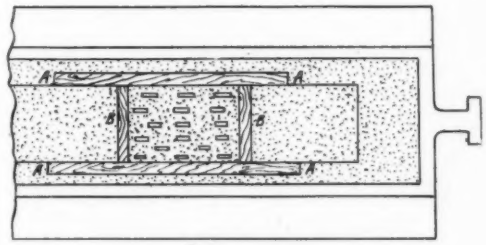
By W. F.

There is scarcely any job that tests the adaptability of a moulder more than the mending of the top part of a mould after an accident, because to a certain extent he has to depend upon his past experience and observation, coupled with his practical knowledge. An example shown herewith is that of an accidental fall or slipping from its place of a section of a girder mould. Of course, in the event of this happening previous to the mould being finished, methods would have been adopted different to that here described; but in this instance the cupola was already charged with the special iron for the girder—hence the necessity for prompt action.

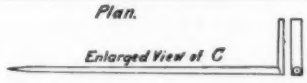
The girder mould in question was finished and ready for closing and the top part or cope was being turned over preparatory to being lowered to its place, when one of the grids supporting a section of the mould broke, causing the section to fall. Fortunately, none of the debris fell in the bottom half of the mould, so the top part of the moulding box was turned back and two pieces of deal boards D, were clamped to the box. The bars of the broken section were then rammed up level, and the mending strips (B B, side view) placed in their position. A glance at the sketch will show the position of



Side View.



Plan.


Enlarged View of C

the other two mending strips, A A, which were held in their place by a weight at the back of them, the strips B B being held in their position by the sections left intact; the space formed by the four strips of wood was then rammed up level.

This brings us to the principal part of the job, viz., the fixing of the replaced section. Referring to the sketch it will be noticed that the method adopted to keep the section rigid is by means of flattened sharps. It may be mentioned, *en passant*, flattened sharps are spikes made of ¼ in. or ⅜ in. round iron, pointed at one end and flattened out at the other and turned about 2 in. at right angles; they are usually used for holding cores in position. A number of these were utilised, care being taken to have them long enough to drive into the deal boards D D. The mending-up strips, A A and B B, were then removed, and the section finished in the usual way.

D

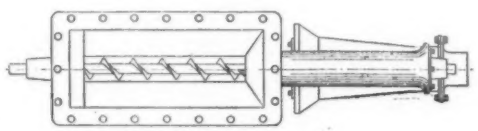
Surface Grinding Machines.

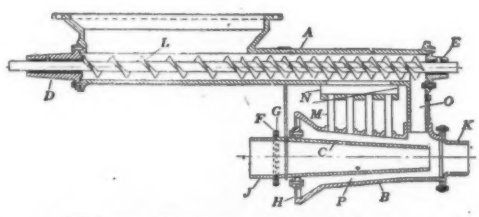
An emery-band surface grinding machine designed to grind and finish work in a straight line, and not in circles as in a disc grinder, is illustrated in the annexed cut, which shows the method of operation. The multifarious uses to which a machine of this type can be put will be apparent. It will be noted that the endless band is kept tight by means of a tension pulley which can be adjusted to take up any slack that may develop in use. The operation of changing the band for one of a different grade occupies only a few seconds and involves no dismantling of the machine parts. The drive is by belt, the requisite speed being 500 to 700 r.p.m. The length of the grinding band is 36 in. and its width 4 in. The table measures 10 in. by 5¼ in., while the driving pulley is 5¼ in. diameter by 1¾ in. wide. It should be noted that our illustration shows a machine of an older style which has since been improved in important particulars, but it gives a good idea of the utility of the machine and its method of operation. The patentee is Mr. Robert H. Lash, 31, Carburton Street, and 30-32, Bolsover Street, London, W.

ENDLESS-BAND SURFACE GRINDING MACHINE.

Powdered Coal Burner.

The use of powdered coal as fuel, restricted for so long to Portland cement practice, is now spreading rapidly. In two Papers submitted by Messrs. David H. Browne and Louis V. Bender, respectively, at a recent meeting of the American Institute of Mining Engineers, descriptions are given of coal-dust-fired reverberatories at Copper Cliff and Anaconda. The coal is crushed, dried and pulverised, and then introduced into the furnace by means of an air current delivered through five "burners" at a pressure of 10 ozs. A secondary air supply is obtained through the port holes through which the burners are projected into the furnace. These port holes are each 12 in. in diameter, which leaves an annular space 3 in. wide around each 6 in. pipe. By means of suitable dampers this secondary air can be regulated. The burners are a special design by Mr. N. L. Warford, of the Anaconda Copper Mining Company. In the annexed cut, A is the screw conveyor housing, B the mixing chamber housing, C the blast-air nozzle, D the drive-end bearing of the conveyor, E the discharge-end bearing of the conveyor, F and G the blast-air control gate, H the free-air control valve or damper, J the sleeve to connect the blast-air pipe, K the sleeve to connect the discharge pipe to the furnace or fire box, L the screw-feed conveyor, and M connecting pipes between conveyor and mixing chamber. The feeding device consists of a screw conveyor enclosed in a dust-tight housing which is bolted to the bottom opening of the coal dust storage hopper, or bin, through which the coal dust is fed into the screw by gravity. The screw carries the coal dust forward to the discharge end of the conveyor housing, where it is discharged into four receiving pipes, through a long narrow slot, and what does not go through the slot passes over and drops through a larger opening at the extreme end of the conveyor housing. The air and coal-dust mixing chamber consists of an outer housing through which a blast-air nozzle extends. The coal dust as it drops from the conveyor housing through the slot is drawn into and through the four pipes on to the blast-air nozzle, and the coal that does not go through the slot drops on to the end of the air nozzle, through the larger opening at the end of the screw conveyor, and all the coal dust entering the mixing chamber is drawn to the end of the blast-air nozzle and blown into the furnace or fire-box.





WARFORD PULVERISED COAL BURNER.

A MEETING of the members of the Midland Counties Institution of Engineers was held at the rooms of the Geological Society, Burlington House, London, W., on June 11. The business was confined to announcing the names of members nominated for election as councillors for the year 1915-16.

Inventions.

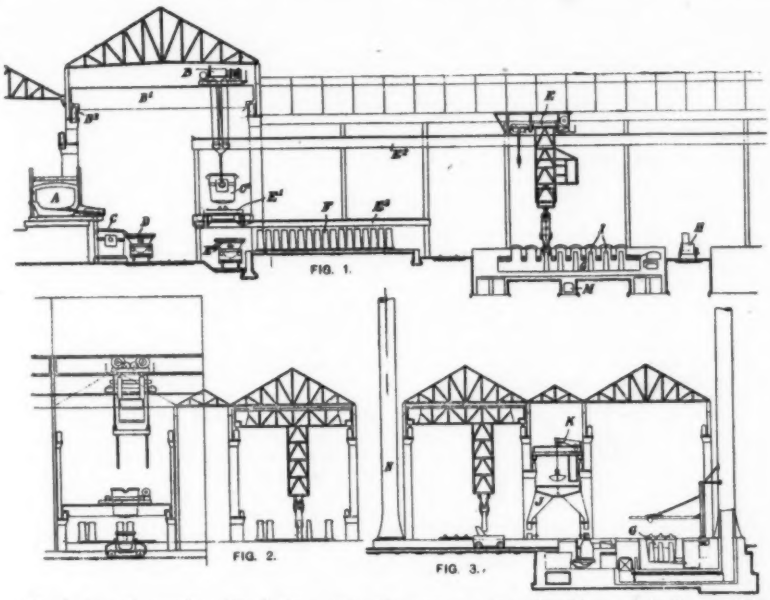
Applications for Patents.

An asterisk indicates that a complete specification accompanies the application. When inventions are communicated the names of the communicators are in brackets.

6,306.*Gripping and forging dies. Locomotive Superheater Company.
6,323 to 6,327. Furnaces. A. Smallwood.
6,328. Furnaces, fire-grates, etc. A. Smallwood.
6,330. Apparatus for introducing goods into, and removing same from, annealing furnaces, etc. A. Smallwood.
6,433. Reverberatory furnaces. F. W. Stevenson.
6,477.*Furnace-mouth closure for blast furnaces. (J. Pohlig Akt.-Ges., Germany.)
6,589. Mandril for use with lathes, grinding machines, etc. S. Scholtens.

Abstracts of British Patent Specification Recently Accepted.

21,066 (1913). *Apparatus for Carrying the Steel from the Steel Furnace to the Roller Mills and for Casting the Ingots en route.* A. H. Cooper. Fig. 1 is a vertical section of the main portion of the plant; Fig. 2 is a vertical section at right angles to Fig. 1 of the casting and reheating pits; Fig. 3 is a section through the reheating pits, shewing also the ingot carriage railway. Referring to Fig. 1, A is the steel furnace, and B a travelling crane running on a gantry B^1. C is a ladle into which the metal is run from the furnaces A, and D is a slag ladle into which the surplus slag from the ladle C overflows. There are a series of stools for the ladles C all along in front of the row of furnaces A. E is a travelling crane running on gantry E^2, preferably at right angles to the main gantrys B^2, on which gantry B^1 runs. The crane E is used for lifting the moulds and the ingots. E^1 is a second travelling crane running on to the gantry E^3, and on which the ladles C^1 are carried over the line of moulds F. There is a slag ladle E^4 on a line of rails into which the remaining slag from the ladle can be poured. G is the soaking pits or reheating furnaces, to which the ingots I are carried by the stripping crane E from the moulds F. The crane E not merely lifts the moulds and carries them to this furnace, but may if desired, be arranged to lift up the lids of the furnaces—although in the arrangement shewn a small hydraulic jib crane has been installed for this purpose. The crane E also lifts the ingots out of the furnaces and conveys them to the ingot carriage H. Referring to Fig. 3 J J are hoppers to which fuel is conveyed by the grab crane K. These hoppers feed the gas producers which generate the gas for heating the soaking pits G. N is a chimney for taking away the spent products of combustion. The ladle when full is transferred by means of an overhead crane on to the teeming crane. The teeming crane travels over the moulds in the drawing and teems its contents into any of them as desired. As soon as the ladle is emptied, the teeming crane moves back out of the way, and the stripping crane which is overhead comes forward and after allowing enough time for the ingots to solidify, the moulds are stripped off and placed on one side in a position ready for receiving another charge of steel, and then the same machine picks up the ingots and transfers them into the heating furnaces. When the ingots are at the proper temperature for the rolling mills, the same stripping and charging crane picks the ingots out of the soaking pits and transfers them on to the ingot carriage which runs forward to the mill and places the ingot on the live rollers in front of the cogging mill. The teeming and stripping crane gantries protrude into the melting shop bay, and are commanded by one or usually two heavy overhead electrical ladle cranes. Also an ordinary gauge railway runs underneath the teeming crane, which enables the slag ladles to be placed underneath the hot metal ladle for the purpose of discharging any slag which may remain after casting. The ignot moulds may be arranged in any way that suggests itself, but as shewn they are arranged so that when stripping operations commence the first mould is taken off and placed in position ready for the next operation of casting. The ingot is then picked up and transferred to the heating furnace. The second mould is then stripped off and placed adjacent to the first mould and the second ingot is transferred to the heating furnaces—this operation going on until the whole cast is dealt with. On the next occasion they are manipulated in reverse order.



Plant for Conveying Steel from the Furnace to the Moulds and Rolling Mills.

Trade Talk.

THE PATERSON ENGINEERING COMPANY, LIMITED, have removed to India House, Kingsway, London, W.C.

MESSRS. TYLER & FREEMAN have removed from 20, New Bridge Street, London, E.C., to 40, Chancery Lane, W.C.

OWING to the difficulty of obtaining castings, a new foundry has been opened at the Glamorgan Collieries, Llwynypia.

PALMERS SHIPBUILDING AND IRON COMPANY, LIMITED, propose to construct new works on the west side of Jarrow Park.

THE Withymoor Works, Netherton, of Swindell & Company, Limited, toolmakers, are being offered for sale by private treaty.

THE CAXTON ENGINEERING, LIMITED, is being wound up voluntarily, with Mr. J. S. King, 19, Chalsey Road, Brockley, S.E., as liquidator.

THE steelworks at Sydney, N.S.W., of the Broken Hill Proprietary Company, were officially opened on June 2 by the Governor-General.

THE last day for receiving proofs in connection with a dividend to be paid by Mr. T. Simm, metal merchant, 234, High Street, Swansea, is July 14.

MR. A. WHITELEY, electrical and mechanical engineer, carrying on business at Tudno Works, Tudno Street, Llandudno, is paying a first and final dividend of 6s. 10½d. in the £.

T. ROWLANDS & COMPANY, LIMITED, steel, iron, and alloy merchants, have removed from the Palm Tree Works, Staniforth Road, Sheffield, to the Windsor Works, North Church Street, Sheffield.

THE discharge from bankruptcy of Mr. W. H. Smith, brassfounder, 56, Goodman Street, Hunslet, Leeds, has been suspended for three years, the debtor to be discharged as from May 31, 1918.

THE average price of pig-iron in the West of Scotland during the three months February—April was 67s. 4.95d., an increase of 8s. 5.95d. on the previous quarter and 10s. 6.95d. on the corresponding quarter of last year.

WILLIAMS, HARVEY & COMPANY, LIMITED, of the Mellanear Works, Bootle, Liverpool, and the Mellanear Tin Works, Hayle, Cornwall, are establishing a tin smelting plant in the States for dealing with Bolivian barrilla.

FIRE broke out on June 10, in a pattern shop at the Hawkhead Works, Hawkhead, Paisley, of Thom. Lamont & Company, Limited, engineers. The brigade succeeded in confining the fire to the part of the works where it originated, the building and contents being destroyed.

THE partnership heretofore subsisting between Mrs. T. Grindrod, as executrix of the will of R. Grindrod, deceased, and E. Thornley, carrying on business as engineers, at Halsalls Yard, King Street, Southport, Lancashire, under the style of the Southport Engineering Company, has been dissolved.

THE council of the Institution of Mechanical Engineers has taken temporary offices at 11, Great George Street, Westminster, S.W., in order that the Government may have fuller use of the Institution's building at Storey's Gate. The High Explosives Committee has had its home there for some months.

THE shareholders of the Malcast Foundry, Limited, have decided that the company be wound up voluntarily, and that Mr. H. Meredith, Prudential Buildings, Corporation Street, Birmingham, be appointed liquidator. As indicated in another column, a new company of the same name has just been formed.

WE understand that Samuel Fox & Company, Limited, of Deepcar, have recently placed a contract with Wellman, Seaver & Head, Limited, of India House, Kingsway, London, W.C., for a complete open-hearth steel plant consisting of three open-hearth furnaces, gas producers, ladle crane, charger, etc.

THE members of the Mining and Metallurgical Club met on Monday at 3, London Wall Buildings, E.C. Mr. Edgar Rickard occupied the chair. The report having been approved, Mr. H. L. Sulman was elected president for the ensuing year and Mr. F. Merricks vice-president, while Mr. S. H. Farrar was re-elected treasurer.

THE trustee of the sequestrated estates of Joseph Phillips & Company, metal merchants, 68, Elcho Street, Glasgow (of which firm J. W. Fullarton was the sole partner), intimates that the Accountant of Court has accelerated payment of a dividend under the sequestration by authorising the same to be made on September 4. Creditors' claims are to be lodged with him on or before August 3.

THE GLASGOW DEAN OF GUILD COURT has granted warrants to William Beardmore & Company, Limited, Parkhead, to erect a one-storey workshop in Rigby Street, Glasgow, a forge near Duke Street, Glasgow, and a one-storey workshop in East Hope Street, Glasgow; to Messrs. David Auld & Son, Limited, engineers, to erect a fitting and a machine shop in Rowchester Street, Glasgow; and to the Steel Company of Scotland, Limited, to erect additions to buildings at Blockairn, Glasgow.

THE MONOMETER MANUFACTURING COMPANY, LIMITED, Whitehouse Street, Aston, Birmingham, have lately received, amongst many others, the following orders: Messrs. Kent Smith and Messrs. Welch & Company, aluminium furnaces; the Northamptonshire Printing Company and Willsons Printing Company, Limited, type metal furnaces; Hadfield's, Limited, the India Rubber, Gutta Percha Telegraph Works Company, Limited, and the M. L. Magneto Syndicate, Limited, Monometer patented heat controllers.

NOTICE is given that, at the expiration of three months, the names of the undermentioned companies will, unless cause is shown to the contrary, be struck off the Register of Joint Stock Companies, and the companies will be dissolved:—Antimony Mining Company, Limited; Argyle Lifting Tackle Company, Limited; Carbide Vanadium Company, Limited; Conveyors, Limited; Cox Brass Manufacturing Company (France), Limited; Sunturbo Engineering Company, Limited; Tungsten Metal Company, Limited; and the Victoria Engineering Company, Limited.

THE question of the arrangements for the manufacture of munitions was discussed at a meeting of the Barnsley and District Chamber of Commerce, which was held on June 9. It was explained that the engineering firms of the town and district were approached a considerable time ago on the question of making shells, but the output offered, about 200 shells per week, was not regarded as adequate, in view of the work of inspection. The proposed effort in Barnsley was rather coldly received, but since the appointment as Minister of Munitions of Mr. Lloyd George, it had been decided that the manufacture should proceed at Barnsley.

AT the request of the Chancellor of the Exchequer, the Commercial Committee of the House of Commons made enquiries as to the conditions prevailing in the import and export trades between this country and Russia. As a result of their investigations the Committee recognised the necessity of establishing a Russian Chamber of Commerce in this country, to promote closer and better relations between British and Russian Commercial Houses, and to remove the difficulties which have hitherto existed and militated against the commercial welfare of the two nations. The Russian Chamber of Commerce in London has now been founded, and has opened offices at 16, Regent Street, W.

THE SOCIETY OF AMALGAMATED TOOLMAKERS, ENGINEERS AND MACHINISTS have issued an appeal urging members "to put in all the time they possibly can, and to be willing (if not employed on Government work) to move to fresh shops and even districts, if by so doing they can assist in accelerating the production of the weapons which are so essential to the success of our troops in the field. Trade unionists may depend upon it that their just interests will be safeguarded to the uttermost, but the shorter the war is the

easier it will be to do this, and we therefore again urge members to strain every nerve in order to ensure the 'delivery of the goods' and the defeat of the enemy."

A NUMBER of new regulations under the Defence of the Realm Act are contained in a supplement of the "London Gazette," issued on June 12, One of these gives power to the Crown to exempt from the Factory and Workshop Act, 1901, any factory or workshop in which the Secretary of State is satisfied that, by reason of the loss of men through enlistment or transference to Government service, or of other circumstances arising out of the war, exemption is necessary to secure the carrying on of work which is required in the national interest. Factories or workshops belonging to the Crown, or where work is being done on behalf of the Crown, are already exempted from the provisions of the Act.

MR. PERCY PITMAN, of 25, Victoria Street, Westminster, London, S.W., informs us that a full sized example of his patent water turbine governor has been loaned to the Science Museum, South Kensington, where it can now be inspected in Room No. 4, of the Machinery Section. Mr. Pitman's patent is a direct connected fluid pressure governor for controlling the speed of water turbines, Pelton wheels, etc. The features claimed are speed regulation, perfect compensation, no floating levers, ball journal and thrust bearings throughout, adjustable while running, automatic, hand or distant control, perfectly balanced valve, a "Live" dash pot (preventing any back action on the valve), and hobbed skew gear running in oil.

IN order to secure the maximum output of munitions from the Manchester district, the local Munitions Committee hopes eventually to keep every available tool busy for 24 hours in every day. To this end it will be necessary not only to employ all the skilled labour that can be obtained, but also to make use of the services of many persons who have hitherto had little or no practical workshop experience. The School of Technology has accordingly arranged with the Munitions Committee to open a register of the names and addresses of all persons who are willing to devote either the whole or some definite part of their time to industrial service of the kind indicated. Those who are able to offer their whole time may expect to be called upon a few weeks hence, so soon as the supply of skilled labour is completely absorbed.

AT the meeting of the Manchester Education Committee, on June 23, Sir Thomas Shann stated that Alfred Herbert, Limited, of Coventry, had lent to the School of Technology a No. 3 combination turret lathe, which had just been completed under the firm's latest designs. The School of Technology, by placing at the disposal of the War Office the expert knowledge of its professors and lecturers, had been rendering valuable service in the production of war material. An opportunity had arisen for assisting the local Munitions Committee, and permission had been given for that Committee to have its headquarters at the school. In addition, the school had undertaken the work of registering the names of persons who were willing to offer their services in producing war material. In order to assist such persons to obtain some workshop training before they entered the works, the School of Technology had arranged a number of special classes.

THE MONMOUTHSHIRE WAR MUNITIONS COMMITTEE met on June 5 to elect the officials, Mr. Felix S. Budd, president of the Newport Chamber of Commerce, presiding. Mr. F. Mills was elected chairman of the Committee, Mr. Isaac Butler vice-chairman, and an executive sub-committee was also appointed, consisting of Mr. G. Mure Ritchie, Mr. W. Trimmer, and Mr. F. W. Raikes, and two Labour representatives, whose names will be given later. Mr. S. D. Williams was appointed secretary to the committee. A request from the Newport Trades Council for the representation of Labour to be increased on the committee from six to nine members was complied with, the following being the names of the members:—Messrs. J. P. Whitehead and A. Taylor (Steel Smelters), W. H. Jones and T. B. Thorne (Amalgamated Engineers), J. Gordon (Steel Workers), A. Leveson (Boilermakers), F. J. North (Moulders and Ironfounders), F. J. Ellis (Steam Engine Makers), and H. Seir. The following were added to the general committee:—Messrs. John Lysaght, Limited (Orb Ironworks), John Paton (Pontypool), Charles H. Bailey (Tyne Engine Works), and Charles D. Phillips (Emlyn Works).

OUR Middlesbrough correspondent writes that an important and largely attended meeting of Tees-side iron and steel manufacturers and engineers was held on June 29 at the offices of the Cleveland Ironmasters' Association, Middlesbrough, to discuss how best to increase the output of munitions in the district. A letter was read from Sir Percy Girouard suggesting that a representative committee should be formed for the purpose of co-operating with the North-East Coast Armaments Committee. A committee was accordingly appointed with power to add to its number. Every employer in the district who has lathes is invited to inspect the process of the manufacture of shells at Messrs. Richardson Westgarth and Company, and Messrs. T. D. Ridley & Sons, and to communicate with Mr. J. T. Atkinson, the secretary, at the Cleveland Ironmasters' Offices, as to the extent to which they can render assistance. Mr. Atkinson will then arrange for a visit of inspection by the Committee. Already, it may be pointed out, a very large quantity of shells is being turned out in this district, as well as much other war material, but there is no doubt that the number of shells manufactured could be greatly increased.

THE danger from furnace explosions arising through the careless use of scrap is pointed out in a communication sent out by the Inspectors of Factories. The chief trouble, it appears, is involved in dealing with hollow tubes, drums, cylinders, and similar vessels, frequently found in scrap metal. Many of these vessels are sealed, and contain water or other liquid, or some explosive mixture of gas and air. When such articles are exposed to the high temperature of the furnace, there is a danger of a violent explosion. Tubes, formerly used in bakers' steam ovens, are sometimes found with the scrap. Some of these are hermetically sealed, and contain water; owing to their thickness, they can easily be mistaken for an ordinary bar of round iron. In one case, a tube, mistaken for such a bar, was plunged into an ingot mould partially filled with molten steel. The tube immediately exploded, scattering the molten metal in all directions, and injuring the workmen. In another case, a hollow pump rod was placed on the hob of a brass-casting furnace to dry it before throwing it into the melting pot. This rod exploded, with fatal results. Iron drums, frequently sent with consignments of scrap, may have been previously used for conveying acids capable of evolving hydrogen by chemical action with the iron, *e.g.*, dilute H_2SO_4 plus Fe equal $FeSO_4$ plus H_2. Such drums, if hermetically sealed, may contain a dangerous explosive mixture. All hollow vessels should be carefully examined before being brought to the furnaces. If sealed, a hole should be carefully drilled and the contents allowed to escape. There is risk in piercing such articles with a sharp pick, or breaking them up with a sledge-hammer, as a spark may be produced capable of igniting any explosive mixture which may have formed inside. As the worker must necessarily be standing over the vessel, there is little chance of escaping the effects of an explosion. The safest plan is to crush such articles under the ball used for breaking up large pieces of iron and steel. There is usually a strong shelter made of boiler plates in these places, where the operatives could be shielded should any explosion occur on the impact of the ball.

THE Board of Trade direct the particular attention of all manufacturers and traders concerned in the export trade to the need for scrupulous care in the transaction of their business abroad. The Government's reprisals policy, formally announced by the Order in Council of March 11 last, is directed to suppress all enemy trade, whether import or export. The main difficulty in making this policy thoroughly effective arises from the fact that some traders in some neutral countries are making themselves agents for the supply of goods to enemy countries. British firms engaged in foreign trade, therefore, must have regard to these circumstances, and survey with great caution every opening for business which is offered them by neutral importers or exporters. Special care should be taken in opening new accounts in neutral countries and in relation to any orders or inquiries of an abnormal character. In any case of doubt as to the *bonâ fides* of particular consignees, business should be suspended pending reference to the Board of Trade. It is inadvisable that any new accounts should be opened by any British trader in neutral countries during the war without the fullest inquiries as to the character of the business proposed to him. The Board feel sure that they can rely upon the cordial co-operation of all firms engaged in foreign business to secure the successful working of the reprisals policy. It must be added that the proclamations relating to trading with the enemy cover indirect trading with the enemy through neutral agents, and that carelessness in transacting neutral business may involve traders in the severe penalties attaching to trading with the enemy.

G. & J. WEIR, LIMITED, of Cathcart, have offered to produce unlimited quantities of shells at net cost. In a letter to the Glasgow and West of Scotland Armaments Committee, Mr. W. Weir pointed out that it was proposed to establish a national shell factory in Glasgow, but that his firm had the nucleus organisation and the necessary experience, so that it would be much simpler to increase their production than to organise an entirely new producing unit. Mr. Weir also stated that the following resolution had been unanimously adopted by the directors of the firm:—"It is hereby agreed that until the conclusion of the war all profits arising from the manufacture of shell under present contracts, after deduction of the necessary allowances for establishment charges and capital expenditure, shall be handed over to certain of the various organisations carrying out relief work or Red Cross work which the war has necessitated, and which are supported by voluntary subscription. When the contracts in question are completed, the different shell plants will be available to produce shell for the Government at net cost, and if required all such future production shall be carried on in conjunction with the proposed Glasgow National Shell Factory." The firm offered to extend their plant and machinery for shell production, and on completion of present contracts to devote machinery and labour to the machining of shell produced by the proposed Glasgow National Factory, or generally to work in conjunction with the same under whatever conditions might be suitable. The Committee expressed its high appreciation of this spontaneous offer, and decided to bring it before the notice of the various interests concerned.

TUNGSTEN.—A process for producing tungsten powder has been patented by Mr. Robert Rafn, of Porsgrund, Norway, and assigned to the General Electric Company. The production of amorphous tungsten powder by reduction of tungsten trioxide is usually difficult of accomplishment, as a crystalline product most often results. The inventor has shown, however, that by making the reduction in two stages, first with ammonia gas at red heat, producing the so-called blue tungsten oxide, and then with hydrogen at cherry-red heat, the resulting product is a tungsten powder of remarkable fineness.

Deaths.

THE death is reported of Herr Emil Rathenau, who founded the Allgemeine Electricitats Gesellschaft, of Berlin. The deceased was 76 years of age.

MR. ROBERT LANG, of the firm of John Lang & Sons, tool and machine lathe makers, Johnstone, died on June 11, aged 60 years. He took an active part in local public affairs, being a member of the Renfrew County Council, and of the Johnstone School Board.

MR. BRYAN CROSSLEY, a director of Crossley Brothers, Limited, of Manchester, has been killed in France. The deceased was the second son of the late Sir William Crossley, Bart., and the only brother of Sir Kenneth Crossley, Bart., the present chairman of the company.

SECOND-LIEUT. J. WILSON, who was killed on May 9, took the degree of B.Sc. Tech. (Honours) in mechanical engineering in 1910 at Manchester University. He was gazetted in October in the Lowland Divisional Engineers, and on proceeding to the front at the end of January became attached to the 1st Lowland Field Company, Royal Engineers.

THE death occurred on June 25, at Prestwood, Stourbridge, of Mr. Thomas Henry Salter, younger son of the late Mr. Thomas Bache Salter, Springfields, West Bromwich, and brother of Mr. Alderman G. Salter, J.P. He was one of the principals of the firm of George Salter & Company, spring manufacturers, West Bromwich.

LIEUT. A. M. OAKDEN, who has died from wounds received in the Dardanelles, was born at Retford and entered Manchester University to study engineering. He was a Whitworth Exhibitioner and a student of the Institution of Civil Engineers. He received his commission in October and was attached to the 1st Field Company, Engineer Unit, R.N.D.

SECOND-LIEUT. J. L. MOFFET, of the 3rd Battalion Royal Scots Fusiliers, who was killed after being at the front for five weeks, took his degree in the Engineering Department of Manchester University. He was awarded by the Institution of Electrical Engineers the premium prize for a paper on "The Possibilities of Electric Traction on Railways."

MAJOR J. F. S. LLOYD, of 6th (Territorial, Burton-on-Trent) Battalion Prince of Wales's North Staffordshire Regiment, was killed in action in Flanders, on June 18. Major Lloyd was the younger son of Mr. Francis Henry Lloyd, of Stowe Hill, Lichfield, who founded the Weldless Steel Tube Company, Limited, of Birmingham, over whose board he presides, and of which the deceased was also a director.

THE death is announced of Sir Arthur T. Lawson, of Bedale Hall, Yorkshire, who died at his London residence, 68, Eaton Square, on June 9, aged 71. He was chairman of the firm of Fairbairn, Lawson, Combe, Barbour, Limited, Leeds, and a director of the Great Eastern Railway. He was created a baronet in 1900, and was a Chevalier of the Legion of Honour.

MR. N. LLOYD, son of Mr. and Mrs. Joseph Lloyd, of Ardvaar, Great Clowes Street, Higher Broughton, has been killed in the Dardanelles fighting. Before the outbreak of war Mr. Lloyd, who was 28 years of age, was an engineer at the Westinghouse Works, Trafford Park. He joined the 6th Manchesters (Territorial Force), and went to Egypt, and afterwards to the Dardanelles.

THE death has occurred at his residence, Lovaine Place, North Shields, of Mr. Samuel Young, for 17 years an assistant departmental manager to Smith's Dock Company, Limited, North Shields. Prior to joining Messrs. Smith's Dock Company, he served with Palmers Shipbuilding and Iron Company, Limited, Jarrow; R. & W. Hawthorn, Leslie, & Company, Limited, Hebburn; and John Readhead & Sons, Limited, South Shields.

THE death occurred on Sunday, June 6, at his residence, Whitelea, Whitegate Drive, Blackpool, of Mr. Peter Pickup, after five months' illness. A native of

Burnley, he resided in Blackpool for over 20 years. His father was manager of the Burnley Ironworks, in which position the son succeeded him and filled for 27 years. Mr. Peter Pickup carried out many enterprises as a mill architect and engineer.

INTIMATION has been received of the death in action of Captain Sir John Fowler, Bart., Seaforth Highlanders. Sir John Fowler, who was 30 years of age, was the grandson of the eminent engineer-in-chief of the Forth Bridge. He was educated at Harrow and Sandhurst, and joined the 2nd Battalion Seaforth Highlanders in 1904. In October, 1913, he was seconded as Adjutant of the 4th Battalion Seaforth Highlanders, which was the first Highland Territorial battalion sent to France from Bedford in November last.

SECOND-LIEUT. H. G. S. DELEPINE, who has been killed in action, is a son of Professor Sheridan Delépine, and entered Manchester University in 1907 to study engineering, afterwards becoming a member of the Officers' Training Corps. After graduating he went to Canada, and returned to Manchester in 1913, becoming junior instructor in drawing and demonstrator in the engineering department of the University. Last summer he accepted a post in the airship department of Vickers, Limited, at Barrow-in-Furness. He was 27 years of age.

Personal.

MR. D. A. THOMAS sailed from England last month for America, in connection with munitions contracts.

THE late Mr. Thomas Farrar, of Devonshire Street, Keighley, brassfounder, left estate valued at £7,632.

THE late Mr. William Wood, of Wood, Skinner & Company, Limited, left estate valued at £37,517 gross.

MR. D. T. JENKINS, of Dowlais, has been appointed to succeed Mr. Jones as manager at the Wishaw Steel Works.

THE late Lieutenant Brian Crossley, a director of Crossley Brothers, Limited, left property valued at £60,213 gross.

THE estate of the late Mr. Arthur Keen, of Guest, Keen & Nettlefolds, Limited, has been provisionally valued at £1,000,000.

COLONEL HERBERT HUGHES, President of the Sheffield Chamber of Commerce, has been appointed Swedish Vice-Consul in Sheffield.

ESTATE of the gross value of £88,236 has been left by the late Mrs. Helen Bell, widow of Mr. Charles Lowthian Bell, of the Cleveland Ironworks.

MR. R. A. E. PAYNE, for twenty-five years a member of the staff of King's Norton Metal Company, Limited, has been appointed manager to the company.

THE late Mr. J. E. Wallis, of Basingstoke, Hants, engineer, ironfounder, and agricultural implement maker, left estate in the United Kingdom valued at £48,741.

THE late Mr. J. N. R. Schott, of Harrogate, steel manufacturer and merchant, left estate valued at £302,873 gross, with net personalty sworn at £296,992.

MR. R. D. LEWIS, of Tettenhall Court, Wolverhampton, has been elected a director of Wm. Roberts (Tipton), Limited, in place of the late Mr. Thos. Cumberland.

CAPTAIN ALFRED HEWLETT, of Wigan, who is reported wounded, is a son of Mr. W. H. Hewlett, J.P., managing director of the Wigan Coal and Iron Company, Limited.

MR. J. HOLLOWAY, works manager at the North British Diesel Engine Works, South Street, Whiteinch, Glasgow, has been injured by being shot by a discharged workman.

THE late Mr. J. K. Wilson, a director of Spear and Jackson, Limited, steel and edge tool manufacturers, of Sheffield, left estate valued at £268,977 gross, with net personalty £248,317.

THE late Mr. James Duffield, of Tallentire Hall, Cockermouth, Cumberland, formerly a director and general manager of Cammell, Laird & Company, Limited, left £454,734 gross and £314,947 net.

MR. FRED OWEN, of Monton, Eccles, near Manchester, ironfounder, who died last November, aged 41 years, left estate of the gross value of £6,956, of which the net personalty has been sworn at £6,399.

THE late Mr. D. A. Louis, F.I.C., F.C.S., of 123, Pall Mall, S.W., mining and metallurgical engineer and chemist, left estate valued for probate at £8,086 gross, of which the net personalty has been sworn at £6,960.

THE gross value of the estate of the late Mr. E. S. Thompson, of Westholme, Codsall, managing director of Thompson Bros., Limited, of the Bradley Boilerworks, Bilston, is £7,735, with £6,651 net personalty.

THE late Captain Stephen Garrett, Suffolk Regiment, of Haylings, Leiston, Suffolk, director of Richard Garrett & Sons, Limited, engineers, who died on March 12 from wounds received in action, has left £9,328.

MR. WILLIAM THACKRAY, a director of Samuel Tyzack & Company, Limited, and chairman of the North of England Manufactured Iron Trade Conciliation and Arbitration Board, who died on March 8, left £52,095.

SECOND-LIEUTENANT T. HOLLAND, R.E., has been appointed by the War Munitions Committee of Monmouthshire as expert adviser in the selection and purchase of machine tools and plant for the manufacture of shells. Lieutenant Holland was previously employed as foreman engineer by the Ebbw Vale Steel, Iron and Coal Company, Limited.

MR. J. H. CANNING, manager of the Newport (Mon.) Gasworks, has been appointed by the High Explosives Committee to organise and direct the work of providing high explosive material in Wales and Monmouthshire. He will be assisted by a committee of gas engineers, including Messrs. H. D. Madden (Cardiff), R. G. Clarry (Swansea), Octavius Thomas (Pentre, Rhondda), J. E. Kenshole (Merthyr), J. H. Swain (Pontypridd), and T. E. Franklyn (Barry Dock).

LIEUTENANT F. C. ALDOUS, reported wounded in the Dardanelles, is the third senior lieutenant in the 6th Battalion Manchester Regiment. He was a draughtsman at the works of the British Westinghouse Electric and Manufacturing Company, Limited, at Trafford Park, Manchester. Second Lieutenant A. Hopkinson, 1st (Royal) Dragoons, son of Sir Alfred Hopkinson, is lying wounded in hospital in London. Lieutenant Eric Hamilton Bedson, of the 8th Lancashire Fusiliers, younger son of Mr. Joseph Phillips Bedson, of Lapwing Lane, Didsbury, was wounded on Monday, June 7, in the Dardanelles, and is now in hospital at Alexandria. Before joining the colours he was in the service of Mr. Harry Burke, engineer, St. Mary's Gate, Manchester.

MR. LLOYD GEORGE, as Minister of Munitions, has now appointed to assist him a very large staff of business men and experts. Exact duties have not yet been allocated, but the following are among the staff:—Sir Percy Girouard, late director of Sir W. G. Armstrong, Whitworth & Company, Limited; Mr. West, another director of the same firm; Mr. Leonard W. Llewellyn, general manager of the Cambrian Combine; Mr. G. M. Booth, shipping expert; Sir Guy Granet, general manager of the Midland Railway; Mr. E. C. Geddes, deputy-general manager of the North-Eastern Railway; Sir Frederick Donaldson, director of Woolwich Arsenal; Lord Moulton, expert in chemistry and explosives; Sir H. Llewellyn Smith, late Permanent Secretary of the Board of Trade; Mr. W. H. Beveridge, director of Labour Exchanges; and Dr. C. Addison, M.P. (to be Parliamentary Secretary of the new Ministry). It is also rumoured that Sir Alexander Kennedy, F.R.S., and Mr. Mever Law have been invited to join the Committee. Both are engineers with world-wide reputations, Sir Alexander Kennedy having been president of the Institutions of Civil, Mechanical and Electrical Engineers.

Parliamentary Notes.

Technical Education.

Mr. Lynch asked the President of the Board of Education, on June 23, whether he could state his intention with regard to the wide educational scheme outlined by his predecessor in office by which it was intended to co-ordinate higher education, and especially higher technical education, with the means of developing industries in this country.

Mr. A. Henderson (President of the Board of Education) said he had no intention of departing from the general policy in this matter initiated by his predecessor, and he hoped to make an announcement on the subject shortly.

Supply of Charcoal.

Mr. Ginnell has asked Mr. Runciman if the Board of Trade had ever tested or watched a test of the process invented by Sir Edward Zohrab for the utilisation of peat, especially for the production of charcoal, and having regard to the price of charcoal at present and the impossibility of producing high-class steel without it, whether he would institute a special examination of the process in question.

Mr. Runciman, in reply, said he had no reason to believe that the manufacture of steel in this country had been restricted by difficulties in obtaining supplies, and he could not in any case undertake to arrange for the examination on behalf of the Board of Trade of patent processes which claimed to be of industrial advantage.

The Price of Spelter and Iron.

Mr. Anderson has asked the President of the Board of Trade whether spelter used in the manufacture of cartridges has been advanced in price from £21 a ton last July to £115 a ton at the present time, an increase of over 500 per cent.; whether in the same period the price of best finished iron in Staffordshire has advanced from £8 10s. to £12 12s. 6d. per ton; whether he will cause thorough investigation to be made as to whether attempts have been made by various interests to corner supplies and force up prices by means of price rings; and whether he will make public the facts as to the prices and profits realised by all the interests concerned out of the present crisis.

Mr. Pretyman: All necessary steps will be taken to guard against any artificial enhancement of price.

Sir Edwin Cornwall asked the Minister of Munitions whether he is taking any steps to secure all possible supplies of spelter, whether for immediate delivery or for delivery over the first six months of 1916. Sir Edwin Cornwall also asked the Minister of Munitions if his duties embrace the provision and regulation of raw material for the use of firms at work on Government contracts for munitions of war.

Mr. Lloyd George: The answer to the first part of the question is in the affirmative. As regards the second part of the question, so far as I am aware, I have all the necessary powers for the purpose. Arrangements have been made with private firms to ensure that metals required for munitions of war are not used for other purposes.

Profits of Armaments Companies.

Mr. Anderson asked the President of the Board of Trade, on June 15, whether his attention had been called to the increase in profit of the King's Norton Metal Company, Limited, from £37,548 for 1913-14 to £131,097 for 1914-15; whether he had yet found a way, as recommended by the Secretary of State for War, to allow the workers to participate in the benefits automatically accruing to these companies from the war; or whether any scheme has yet been devised and put into operation for the limitation of war profits.

Mr. Runciman: The profits of this company for 1913 14 were as stated in the question; but the Board of Trade have no information as to the profits for the subsequent year. The whole question of the method of limitation of the profits of armament firms is now being considered by the Government.

Mr. Snowden later asked the Chancellor of the Exchequer if he was aware that the King's Norton Metal Company had declared profits showing an increase of 250 per cent. on the previous year; that such increase had been made during two-thirds of the year only; that this firm's special work was the manufacture of war munitions; and would he say if it was proposed to socialise these increased profits for the relief of the general taxpayer, in view of the burden of the cost of the war and the increase in the cost of living?

Mr. McKenna, in regard to the first part of the question, referred to an answer given by the President of the Board of Trade on June 14, and, as to the latter, said he understood the firm in question was specially engaged in the manufacture of war munitions. The whole question of increased profits was under consideration.

Cast-Iron Shells.

Mr. R. P. Houston asked the Minister of Munitions on June 16, whether he was aware that one of the most destructive and effective shells used by the Germans against our trenches was a cast-iron shell filled with high explosives, and that this shell was more easily, cheaply, and quickly produced than our steel shrapnel shells; and whether he would arrange that our troops were promptly provided with an abundant supply of the same class of shell as the Germans were using, or an improved type.

Mr. Tennant, who replied, said:—I am not aware that the most destructive and effective shells used by the Germans are made of cast-iron. I would point out to the hon. member that there is no lack of production of shell bodies, and that it is the production of other components that entirely governs the output. Whether, therefore, the shell is made of cast-iron or forged steel, and there are technical objections to the former, the complete round of ammunition would not be produced with greater rapidity.

Mr. Houston on June 23 further asked whether is was a fact that there was only a limited quantity of machinery in the country which could turn out steel shells for artillery; whether this machinery was practically confined to Government arsenals and armament firms regularly engaged in the manufacture of steel shells; whether there was an abundance of machinery in the country which could easily be used or converted for the manufacture of cast-iron shells.

Dr. Addison (Parliamentary Secretary Ministry of Munitions), in reply, said that the question of the existing supply and distribution of machinery for making shells was being considered by the Ministry of Munitions of War, which was anxious to take full advantage of all suitable machinery. It had been stated, the War Office informed him, that the Germans were using cast-iron or cast-steel shells, but no special inquiry had been made.

Prohibited Exports.

A special supplement to the "Gazette" announces that the following are added to the list of goods which must not be exported to any places except British possessions and protectorates:—Steel containing tungsten or molybdenum or both, and any tools or other articles made from such steel.

The new Order also prohibits the export to Norway of "tinplates, including tin boxes and tin canisters for food packing." The export of these things to Denmark, the Netherlands, and Sweden had already been forbidden.

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REDISTIK FILLET
"TAPIX"
EVANS
JAMES EVANS & Co. BRITANNIA WORKS,
BLACKFRIARS, MANCHESTER.

New Companies.

National Engineers' Supply Company (Liverpool), Limited.—Capital £2,000 in £1 shares.

John Wolstenholme & Son, Limited.—Capital £15,000 in £5 shares, to carry on the business of engineers.

Excelsior Foundry Company, Limited.—Capital £10,000 in £1 shares. Registered office: Lenton Street, Sandiacre, Derby.

British Drill and Engineering Company, Limited.—Capital £5,000 in 4,000 "A" shares of £1 and 4,000 "B" shares of 5s. Registered office: 8, Waterloo Place, London, S.W.

W. S. S. Syndicate, Limited.—Capital £50 in 1s. shares, to take over the business carried on by the Rennie Forrest Shipbuilding, Engineering and Dry Dock Company, Limited.

Fullwood Foundry Company, Limited.—Capital £30,000 in £1 shares, to carry on the business of iron and steel manufacturers, coalmasters, etc. Registered office: 3, Merry Street, Motherwell.

British Bachelet Ordnance Company, Limited.—Capital £50,000 in £1 shares, to adopt an agreement with C. R. Howes, 42, Piccadilly, W. Secretary: W. E. Newell. Registered office: 166, Piccadilly, W.

Rubel Bronze (1915), Limited.—Capital £100,000 in £1 shares, to carry on the business of manufacturers of and dealers in alloys, bronze ingots, castings, etc. Registered office: 82, Victoria Street, S.W.

Mechanical Supplies, Limited.—Capital £1,000 in £1 shares, to carry on the business of mechanical engineers, etc., and to adopt an agreement with F. W. Baynes. Registered office: 17, Lime Street, London, E.C.

Malcast Foundry (1915), Limited.—Capital £1,000 in £1 shares, to take over the business carried on by the Malcast Foundry. The first directors are W. Foggo and S. A. Cosgrave (both permanent). Registered office: The Crescent Works, Pleck Street, Walsall.

Semple & Company, Limited.—Capital £1,000 in £1 shares, to acquire the business of electrical and mechanical engineers carried on by Semple & Company, 170, Hope Street, Glasgow. The first directors are R. Semple and J. H. Ballantyne. Registered office: 170, Hope Street, Glasgow.

Iowa Engineering Company, Limited.—Capital £1,500 in 1,000 part preference shares of £1 each and 10,000 ordinary shares of 1s. each, to carry on the business of electrical, mechanical, hydraulic and general engineers and contractors. Registered office: 74, Vauxhall Bridge Road, London, S.W.

David Etchells & Son, Limited.—Capital £20,000 in £1 shares, to take over the business of an engineer and machinist carried on by D. Etchells at the Bull Piece Works, Darlaston. The first directors are D. Etchells and D. H. Etchells (both permanent). Registered office: Bull Piece Works, Darlaston.

W. C. Carter & Moore, Limited.—Capital £100 in £1 shares, to carry on the business of consulting, marine, mechanical, and electrical engineers, etc. The first directors are W. C. Carter (chairman) and W. H. Moore. Secretary: H. Crafter. Registered office: Vernon House, Sicilian Avenue, Bloomsbury Square, London, W.C.

Rennies Steel Castings Company, Limited.—Capital £30,000 in 15,000 preference and 15,000 ordinary shares of £1 each, to acquire the business of steel founders carried on at Tollcross, Glasgow, as Rennie's Steel Castings Company. The first directors are D. Rennie and G. Rennie. Registered office: Mackinfauld Road, Parkhead, Glasgow.

Beddies, Limited.—Capital £10,000 in £1 shares, to acquire and carry on the brassfounding branch of the business of James Milne & Son, Limited, Milton House Works, Edinburgh, and the business of brassfounders at present carried on by John Beddie & Sons at 56A, Fountainbridge, Edinburgh. Registered office: 22, Milton Street, Edinburgh.

Williams (Metals) Limited.—Capital £3,000 in £1 shares, to acquire the business of metal merchants, manufacturers of ingot brass, spelter, pig and bar lead, etc., carried on by Walter J. Williams and Mrs. R. A. Morris at Gunbarrel Works, Witton Road, Aston, Birmingham, as W. Williams & Company. Registered office: Gunbarrel Works, Witton Road, Aston.

Pen-y-Pass Copper Company, Limited.—Capital £1,290 in 1,200 participating preferred or "A" shares of £1 each and 1,800 deferred ordinary or "B" shares of 1s. each, to take over the tributors' rights required by J. F. Wells, of 56, Moorgate Street, London, E.C., to work a certain copper mine at Pen-y-Pass, Wales. Registered office: 56, Moorgate Street, London, E.C.

Burdon Oil Gas Furnaces, Limited.—Capital £55,000 in £1 shares, to take over the business formerly carried on by John Burdon & Sons at Caldervale Works, Bellshill, Glasgow, as engineers and manufacturers of the patent Burdon oil-gas furnaces and the patent Burdon oil-gas producers, etc. The first directors are R. Campbell, W. M. Burdon, D. M. Anderson, and A. J. Wilson. Registered office: 23, King Street, London, E.C.

Willoughby (Plymouth), Limited.—Capital £25,000 in £1 shares, to acquire and turn to account the business and properties of Willoughby Brothers, Great Western Docks, Plymouth, to carry on the business of makers, melters, forgers, rollers, casters, and converters of steel and other metals, etc., and to adopt an agreement with R. W. C. Barber, C. H. James, W. Hexter, B. W. Stedham, and J. B. James. The first directors are J. B. James, C. H. James, B. W. Stedham, W. Hexter, and R. W. C. Barber. Secretary (*pro tem.*), G. F. Reckett. Registered office: Central Engineering Works, Rendle Street, Plymouth.

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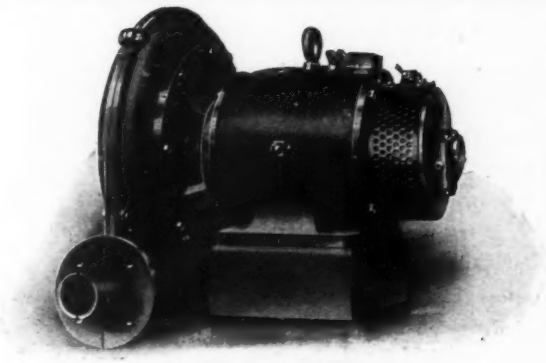

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Some Points worth noting.

Owing to few wearing parts, the Fans are not liable to break down. The mechanical efficiency is high and remains so. The pressure is steady and the volume even and free from pulsations.

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BELFAST.

ELDER'S FOUNDRY COKE

AS SUPPLIED TO THE
BRITISH
ADMIRALTY DOCKYARDS.

The following, selected from numerous letters, are eminent testimony as to the quality of our celebrated "A.A.A." Coppee Foundry Coke, carefully selected, and despatched in sheeted wagons.

From PECKETT & SONS, Bristol.

Bristol, October 25th, 1904.

We have been using your Selected Foundry Coke for some considerable time.
We have pleasure in stating that we are very pleased with it, as we find we get sounder and cleaner castings, more free from blowholes and other defects, than we formerly did.

From BOW, McLACHLAN & CO., LTD. (Paisley Foundry), Paisley, Glasgow.

Paisley, 12th March, 1909.

We have yours of 4th inst., and in reply have pleasure in stating that we have been using your Foundry Coke for several years for special purposes with highly satisfactory results.

Celtic Collieries, Ltd., Cardiff.

Telegraph: "OUTPUT, CARDIFF." Telephone: 4640 & 4641.

MONTHLY PRICE LIST.

The undermentioned prices, unless otherwise specified, are those obtaining on the first day of the current month.

Pig-iron.

Cleveland.

	July 1 s. d.
Cleveland No. 1	71 6
,, No. 3	67 0
,, No. 4 foundry	66 6
,, No. 4 forge	66 0
,, Mottled	66 0
,, White	66 0
East Coast hematite, mixed Nos.	100 0
Cleveland warrants	66 9½

Above prices are for early f.o.b. deliveries and as regards Cleveland iron are for G.M.B. brands. The warrant quotations are the sellers cash prices.

Scotland.

	s. d.
Standard Foundry (Glasgow Market settlement price)	66 4½
Warrants, ditto	72 9

Makers' prices:—	s. d.		s. d.
Gartsherrie No. 1	85 0	No. 3	81 0
Coltness No. 1	102 0	No 3	82 0
Summerlee No. 1	85 0	No. 3	80 0
Langloan No. 1	85 0	No. 3	80 0
Calder No. 1	80 0	No. 3	75 0
Clyde No. 1	86 0	No. 3	81 0
Carnbroe No. 1	83 0	No. 3	79 0
Monkland No. 1	81 0	No. 3	79 6
Shotts No. 1	82 6	No. 3	77 6
Govan No. 1	75 6	No. 3	74 6
(All deliverable alongside Glasgow.)			
Glengarnock No. 1	86 0	No. 3	81 0
(Deliverable alongside Ardrossan.)			
Dalmellington No. 1	82 0	No. 3	80 0
Eglinton No. 1	80 0	No. 3	79 0
(Deliverable alongside Ayr.)			
Carron No. 1	85 0	No. 3	81 0
(F.a.s. Grangemouth.)			

Lancashire.

	s. d.	s. d.
Lancashire No 3 foundry f.o.t.	—	—
Lincolnshire No. 3 foundry	—	76 9
Derbyshire No. 3 foundry	73 6	75 0
Staffordshire No. 3 foundry	73 0	73 6
Cleveland No. 3 foundry	75 8	76 2
(All delivered equal Manchester.)		
Scotch No. 3 — Gartsherrie	—	88 6
Scotch No. 3 — Glengarnock	85 0	87 0
Scotch No. 3 — Eglinton	—	Nom.
Scotch No. 3 — Summerlee	—	86 0
(Delivered Manchester Docks.)		

North-West of England.

	s. d.	s. d.
Bessemer mixed numbers net f.o.b.	105 0	107 6
Hematite warrant net cash	—	95 0
Lorn cold-blast charcoal iron	180 0	190 0

The Midlands.

	s. d.	s. d.
Staffs. Common forge	67 0	68 0
Staffs. Part Mine forge	—	72 6
Staffs. Best All Mine	97 6	100 0
Staffs. Cold Blast	—	155 0
Northampton foundry	—	—
North Staffs. foundry	—	—
Derby foundry	—	—
Nottinghamshire foundry	—	—
Leicestershire foundry	—	—
Shropshire Cold-Blast	—	—

Strong forge, about 1s. less than grey forge; Mottled and White, about 2s. less than forge; Foundry No. 3, 3s. to 5s. above forge; No. 1 and No. 2, from 1s. 6d. to 2s. above No. 3; No. 1, about 2s. above No. 2.

(Delivered South Staffordshire Works, net cash monthly.)

Lincolnshire.

	s. d.	s. d.
Forge	—	—
Grey forge	—	—
Basic	—	—
No. 3 foundry	—	—
No. 4 foundry	—	—

F.o.t. Makers' works.

South Wales.

	s. d.	s. d.
Welsh Hematite	105 0	107 6

Ferro-Alloys.

Net, Delivered Sheffield Steel works.

	£ s. d.
Ferro-chrome: 4/6% carbon. Basis 60%, scale 10s. per unit. Per ton	28 0 0
Ferro-chrome: 6/8% carbon. Basis 60%, scale 10s. per unit. Per ton	26 10 0
Ferro-chrome: 8/10% carbon. Basis 60%, scale 8s. 6d. per unit. Per ton	25 0 0
Ferro-chrome: Specially refined, guaranteed maximum 2% carbon, broken to small pieces for use in best quality crucible steels. Basis 60%, scale 22s. per unit. Per ton	70 0 0
Ferro-vanadium: 33/40% Va., per lb. of Va. contained in the alloy	0 9 0
Ferro-silicon: 45/50%. Basis 50%, 5s. scale per unit .. Per ton	14 15 0
Ferro-titanium: 15/18%, per pound, flat	0 0 6½
Ferro-molybdenum: 70/80% Mo. per pound of Mo. contained	0 18 0
Ferro-phosphorus: 20/25%. Per ton	16 10 0
*Ferro-manganese 80%	20 0 0
,, export	—

* F.o.b. Liverpool.

Iron Castings.

Cleveland.

	£ s. d.	£ s. d.
Columns (plain)	7 7 6 to	7 12 6
Pipes, 1½ to 2½ in.	7 0 0	7 5 0
,, 3 to 4 in.	6 10 0	6 15 0
,, 5 to 8 in.	6 5 0	6 7 6
,, 10 to 16 in.	6 5 0	—
,, 18 to 24 in.	6 5 0	—
Chairs	4 7 6	4 10 0
Floor plates (open sand)	3 10 0	3 12 6

(At work).

Non-Ferrous Metals.

Copper.	£ s. d.	£ s. d.
Standard, Cash	79 2 6	79 7 6
Three months	80 7 6	80 12 6
Electrolytic	95 0 0	94 0 0
Tough	91 0 0	92 0 0
Best selected	91 0 0	92 0 0

Tin.		
Standard, Cash	170 15 0	171 5 0
,, Three months	166 0 0	166 10 0
English Ingots	171 0 0	172 0 0
Bars	172 0 0	173 0 0
Refined	—	175 0 0

Spelter.		
American	—	110 0 0
Specials	—	—
Hard	—	62 0 0
British	—	110 0 0

Lead.		
Soft foreign	—	25 0 0
English	—	26 0 0

Antimony.		
Regulus	—	125 0 0

Aluminium.		
Virgin Metal, 98/99% per ton	86 0 0	

*Chromium (Metallic).		
98/99% purity per lb.	—	

*Nickel.		
In cubes, 98/99% purity Per ton	220 0 0	

*Tungsten Metal Powder.		
96/98% purity per lb.	0 6 3	

*Molybdenum Metal.		
96/98% purity per lb.	—	

*Cobalt Metal.		
97% purity per lb.	0 7 6	

Quicksilver.		
75 lb. bottle	16 15 0	

* Net, Delivered Sheffield Works.

Scrap Iron and Steel.

Cleveland.

	s. d.	s. d.
Steel scrap, heavy melting	67 6 to	70 0
Iron scrap cast (cupola metal)	59 0	62 0

London (f.o.b.).

Heavy steel	60 0
Light ,,	50 0
Heavy cast	60 0

Non-Ferrous Scrap.

London merchants quote the following prices for scrap metal, delivered London, and subject to market fluctuations:—

	A. Joseph. £ s. d.
Hy. Electrolytic Copper Scrap	90 0 0
Hy. Selected Scrap Brass	70 0 0
Hy. Tinn d Copper Wire	76 0 0
Best Selected Gunmetal Scrap	75 0 0

Re-melted Ingot Lead 30s. under English Lead price on date of order.

Stocks.

Pig-Iron in Public Store.

	July 1. Tons.	Inc. + or Dec. — since 1914. Tons.
Connal's at Glasgow Scotch	1,000	No change.
Ditto other makes	—	— 2
Connal's at Middlesbrough	152,281	+ 73,992
Connal's at Middlesbrough, hematite	—	No change.
West Coast hematite	2,605	— 3,025

Metals.

Copper, Europe and afloat	33,041	+ 4,770
Tin, London Holland, U.S.A. and afloat	18,206	— 363

Coke.

Middlesbrough.

	s. d.	s. d.
Gas Coke	unobtainable.	
Foundry Coke	35 0 to	40 0
Furnace coke	—	30 0

Newcastle-on-Tyne.

FOUNDRY COKE—	F.o.b. s. d.	Dunston. s. d.
Original Garesfield	—	37 6
Mickley	—	37 6
Stella Garesfield	—	37 6
Priestman's Garesfield	—	37 6
Consett Garesfield	—	37 6
Newcastle gas coke	—	27 6

Cardiff.

	s. d.	s. d.
Special foundry coke	40 0 to	42 0
Foundry coke	34 0 to	38 0
Furnace coke	30 0 to	32 0

Leeds.

Furnace coke (washed)	—	25 0

Birmingham.

Foundry coke	—	—
Furnace ,,	—	—
Gas ,,	—	—

Glasgow.

Foundry coke	—	30 0
Furnace ,,	—	24 0
Gas ,,	—	—

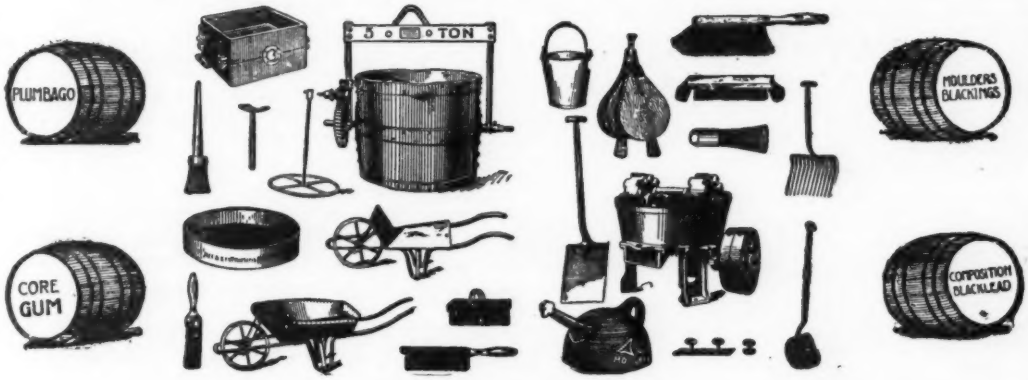
London.

Welsh or Durham Foundry, d/d London Stations, in truck	—	47 0
Yorkshire, d/d London Stations, in truck	—	36 0

Established 1863.

JAS. DURRANS & SONS,

Phœnix Works, Penistone, Near Sheffield.



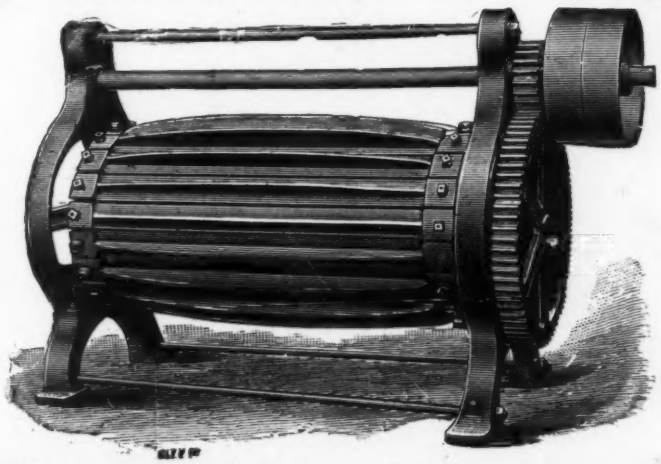
Manufacturers of all

FOUNDRY EQUIPMENTS

COMPOSITION BLACK LEAD, PLUMBAGO, CORE GUM, WHITE DUST & COAL DUST

Ladles, Cupolas, Fire Bricks, Gannister, Stone Flux, Loam and Sand Mills, Casting Cleaners, Studs, Chaplets, Pipe Nails, Sprigs, Brushes, Wire Brushes, Core Ropes, Bellows, Buckets, Spades, Forks, Riddles, Sieves, Barrows, Etc.

Improved Foundry Rattler or Fettling Drum.



These Machines are invaluable for a Foundry, doing a larger amount of work of a superior quality, in a much shorter time than can be done by hand, without skilled labour.

The following testimonial explains itself :—

"Dear Sirs,—We have been using your best Blacking for a large number of years, and always use it on our large Ingot Moulds, which, as you know, we have made up to 85 tons in weight.

Yours faithfully, THE BRIGHTSIDE FOUNDRY & ENGINEERING CO., LD.

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— SPECIALISTS — IN FOUNDRY WORK.

Laboratory for all kinds of Metallurgical Investigations.

NAISH & CROFT,

150, Alma St., BIRMINGHAM. | 24, University Mansions, Putney, LONDON, S.W.

PLUMBAGO — CRUCIBLES.

Parting Powder.

William OLSEN

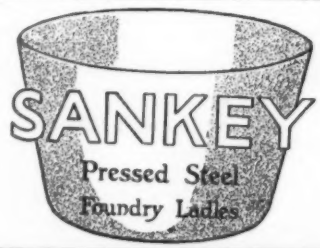
CORE ROPINGS

STRAW AND WOOD, all sizes, quick Delivery.

COCAN STREET, **HULL.**

Wax Core Vent.

GLUTRIN — CORE GUM.



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SEAMLESS PRESSED STEEL

FOUNDRY LADLES

Plain or Lipped: Made in any capacity from ½ cwt. to 4 cwts. Write for Details.

JOSEPH SANKEY & SONS LTD., HADLEY, SALOP.

THE "LEEDS" COMBINED HAND-PRESS & TURNOVER MOULDING MACHINE

Taking Boxes up to 22 inches by 14 inches.

Invaluable in the Foundry for a large variety of work.

As supplied to His Majesty's Government.

We also supply

ROTARY CORE MACHINES (British made)

PISTON CORE MACHINES (for large cores)

CORE OVENS.

CUPOLAS.

CRUCIBLE FURNACES.

MOULD DRYERS (Portable).

MOULDING MACHINES (of all types).

SAND MIXERS.

TUMBLING BARRELS.

ETC., ETC.

HORACE P. MARSHALL & CO., FOUNDRY SPECIALISTS. LEEDS.

Telegrams: "Specialty, Leeds." Telephone: 1909.

SITUATIONS VACANT AND WANTED.

MOULDER, used to general, light, and medium Castings, desires responsible position or favourable change. Has some technical knowledge, acquainted with plate and machine. Age 33, married, temperate.—Apply Box No. 568, Offices of THE FOUNDRY TRADE JOURNAL, 165, Strand, London, W.C.

FOUNDRY FOREMAN.—GOVERNMENT WORK. Wanted, to take charge of a small Foundry engaged chiefly upon investigation work, but having some production, a first-class man with all-round experience of iron, bronzes and aluminium, methods, processes, and costs. Varied experience in the car and cycle motor lines would prove advantageous. No man on Government work need apply.—Write or apply nearest BOARD OF TRADE LABOUR EXCHANGE, mentioning this paper and No. A472.

IRON FOUNDRY MANAGER (age 29 years) desires change; can take entire charge of works; quoting prices and getting out costs done systematically; would travel and break new ground.—Apply Box 572, Offices of THE FOUNDRY TRADE JOURNAL, 165, Strand, London, W.C.

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SCRAP METALS.

MESSRS. C. A. ROBINSON & CO., Anchor Iron Wharf, East Greenwich, S.E., are Cash Buyers of every description of Scrap Iron and Steel, Brass, Copper, and all Metallic Residues.—Telephone, No. 94 Deptford.

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TO BRASS FOUNDERS AND OTHERS.—For SALE, almost new HAND MOULDING MACHINE, SAND MILL, ROTARY SIEVE, First-Class GAS ENGINE, LATHES, and other Machines.—Apply Box 490, Offices of THE FOUNDRY TRADE JOURNAL, 165, Strand, London, W.C.

CUPOLAS, 3½ ft. and 6½ ft. diameters; Steam Hammers, 3, 7, and 25 cwts.; Platt's "Hercules" Power Hammer, 160 lbs.—BARNETT, 44, Albany Road, Wolverhampton.

BLOWERS.—Three 2-in. Keith Blackman's, and one engine-driven, 7 in. by Roots; 36 in. Fan, 14 in. outlet, and 6 in. Dempster Gas Exhauster.—Address, Box 575, Offices of THE FOUNDRY TRADE JOURNAL, 165, Strand, London, W.C.

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HENSHAW ROAD, SMALL HEATH. **BIRMINGHAM.**

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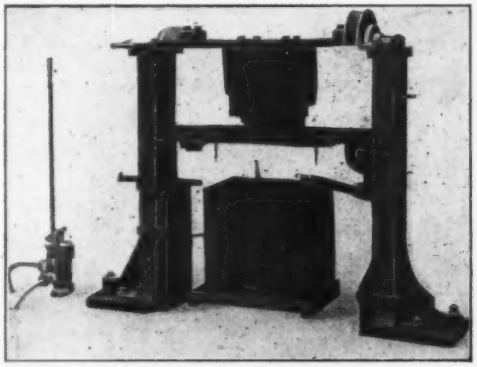
THE "CHIPCHASE" PATENT

MOULDING MACHINE.

(HYDRAULIC or PNEUMATIC)

SIMPLE - STRONG - DURABLE



This illustration shows the 3rd position in the making of axle boxes.

THE "CHIPCHASE" PATENT JARRING MACHINE.

THE "CHIPCHASE" PATENT CORE MAKING MACHINE.

Sole Makers—

DAVID BRIDGE & Co., Ltd.,

CASTLETON FOUNDRY, CASTLETON, MANCHESTER.

38½"
McNEIL'S
PATENT UNBREAKABLE
STEEL LADLES
These Ladles are manufactured by a patented process, each from a single steel plate without weld or rivet. They are extremely light, being at the same time the strongest and most durable in the market. Ladles to contain 56 lb. of metal only weigh about 7 lb. each. They are made of all capacities from 30 lb. to 60 cwt., with or without lips; also mounted or unmounted. They are also suitable for chemical and metallurgical processes. List of sections and prices on application to
CHAS. McNEIL.
KINNING PARK IRONWORKS,
GLASGOW.
36"
32½"

CAN ALSO BE MADE IN ALUMINIUM.

Kindly mention this paper when enquiring or ordering.

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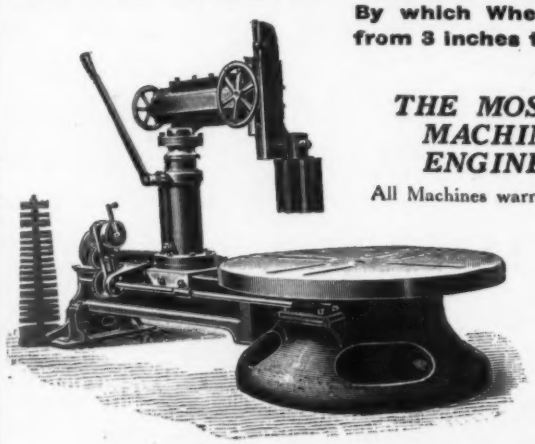
By which Wheels or Pulleys of any description or size from 3 inches to upwards of 20 ft. diameter can be made.



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